# NATURAL RESOURCE USE AS A COPING AND ADAPTATION STRATEGY TO FLOODS OF VULNERABLE POPULATIONS IN THE EASTERN CAPE

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by

**Mwazvita Tapiwa Beatrice Sachikonye**

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Supervisor: Professor C.M. Shackleton

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## DECLARATION

I, Mwazvita Tapiwa Beatrice Sachikonye, hereby declare that the work described in this thesis was carried out in the Department of Environmental Science, Rhodes University under the supervision of Prof. Charlie Shackleton. The various components of the thesis comprise original work by the author and have not been submitted to any other university.

Sach.

**Mwazvita Tapiwa Beatrice Sachikonye**
**14 November 2014**

# ABSTRACT

Many of the anticipated increased occurances of natural hazards are not only a consequence of climate change, but rather of rapid and widespread land cover change and the subsequent loss of the buffering capacity provided by healthy ecosystems against natural hazards. Unplanned and unmanaged developments in informal settlements limit government's ability to mitigate and manage, pointing towards natural resources as being integral for vulnerable communities in developing countries to cope with and mitigate flood disasters. There is a lack of understanding on how natural resources contribute to resilience of vulnerable populations in the Eastern Cape and how they are impacted by these populations before, during and after a flood shock. There also exists a gap in knowledge on how natural resources can mitigate the physical impacts of flooding in South Africa, more so in the Eastern Cape province.

Using household questionnaires and GIS techniques, the strategies that households used to recover from the October 2012-February 2013 flood shocks were investigated in informal settlements of three towns (Grahamstown, Port Alfred and Port St Johns). Within the vulnerability paradigm and the sustainable livelihood framework, the study also quantified and evaluated the relative contribution of natural resources to recovery strategies, and lastly, the study investigated how patterns of land use, state of natural vegetation and household topographical location exacerbated or diminished the physical impacts of flooding.

This study found that natural resources contributed up to 70 % to recovery of households from the flood shock, most of this being to reconstruction of housing structures after the flood, less so to economic recovery. It was also found that at a settlement scale the buffering effect of vegetation, although variable amongst settlements, was significant. Settlements that were dominated by dense bush and small trees experienced up to 46 % less impacts on their property than those surrounded by bare gravel and impervious roofs with degraded environments.

The main findings of the research show that natural resources reduce the vulnerability of households in informal settlements to flooding in two significant ways; by physically mitigating against damage to shelters and by also providing an emergency-net function that substitutes financial capital in households. Their inclusion in disaster management has the potential to encourage the sustainable livelihoods of the urban poor in the Eastern Cape.

# CHAPTER 1. GENERAL INTRODUCTION

"…from hurricanes and floods in Latin America to earthquakes in Asia, natural disasters are increasingly becoming a regular feature of life for large numbers of people around the globe." *Earl Blumenauer*

**Plate 1.** Impact of floods in New Rest, Port Alfred informal settlement (Source: SABCNews.com)

## 1.1 Chapter overview

This chapter presents the theoretical framework of this study. It sets the scene of the flood events which occurred in the Eastern Cape province of South Africa in October 2012 to February 2013 as the focus of this work. In this chapter, the broader literature surrounding vulnerability, sustainable livelihoods and coping and adaptation to the stressors and subsequent shocks of climate change are discussed. The chapter begins by discussing the occurrence and consequences of floods globally, and then focuses this on southern and South Africa, and gives an account of the specific October 2012 and February 2013 flooding event in the Eastern Cape province. It then goes on to present the various issues surrounding disaster management in South Africa, before it proceeds to present the problems of land use and degrading natural 'vegetation-scapes' and how these contribute to higher flooding incidence and greater impacts thereof.

The chapter then discusses how ecosystem services help to prevent both the occurrence and the impacts of flooding, and also introduces the socio-economic dimensions of disaster occurrence and impact. Vulnerability is thus conceptualised into the flooding narrative and the sustainable livelihood framework within which this study is framed and discussed, and the problem with which this study was concerned is presented, after which the chapter concludes by presenting the study aim, objectives and key questions.

## 1.2 Floods as natural disasters and their distribution

Guha-Sapir & Hoyois (2012), show that the occurrences of natural disasters is increasing. This increase is thought to be a consequence of climate change because, of the total recorded disasters in EM-DAT 2012, over 90 % are hydro-meteorological events (Centre for Research on the Epidemiology of Disasters (CRED) in the EM-DAT 2012 database). Scientific evidence suggests these events are strongly linked to climate change, and will become more frequent and intense as global climate change advances (Giupponi et al., 2014). Hydro-meteorological events such as storms (including cyclones, typhoons and hurricanes), droughts, floods and wet landslides, account for between 70–90 % of all disasters recorded in the last decade. In 2010, 92 % of the worldwide total of natural disasters was due to hydro-meteorological events (Guha-Sapir & Hoyois, 2012). These events also accounted for almost 63 % of the global total economic losses in 2010. Statistics show that storms and floods alone account for about 70 % of all natural disasters worldwide. EM-DAT 2012 show a decrease in flood incidences over the last five years, although these same flood incidences still account for 145 of the average 370 per year of all geophysical and meteorological disaster incidences recorded for the same period (Guha-Sapir & Hoyois, 2012).

Guha-Sapir & Hoyois (2012) contented that floods and storms are especially disconcerting as they tend to affect a larger number of people in comparison to other disasters such as earthquakes. This is because floods are concentrated in highly populous countries and the damage is therefore less contained (Jennings, 2011). Paul (2011) describes Cyclone Sidr that struck Bangladesh in 2008, with damages estimated at US$1,2 trillion. Moreover, highly populous countries such as those in south-east Asia are generally not wealthy, thereby limiting the extent of their preparedness for disaster resulting in little mitigation of the impacts of flood disasters on populations (Dellink et al., 2008).

All countries are vulnerable to climate change and unstable, erratic weather patterns; but the severely poor of the poorest countries are most vulnerable as they are the most exposed with the least means to adapt (Douglas et al., 2008). There is an economic dimension to the occurrence and to the impacts of flood disasters (Figure 1.1). Wisner et al. (2004) put forward that population distribution also affects the ways in which these occurrences happen. Guha-Sapir & Hoyois (2012) support this, reporting that in the last five decades, two out of every five disasters occurred on the Asian continent especially south and south-east Asia. High population densities located in disaster prone areas such as coast lines, large river basins and seismic areas exacerbate the impacts and occurrences of natural flood disasters (Burton et al., 1978; Wisner et al., 2004).

### 1.2.1 Flooding in southern and South Africa

Climate change appears to be altering the pattern of flooding in Africa. Climatic modelling reveals that the pattern of unusual flooding is going to change much more than long-term average river flows (Douglas et al., 2008). Many African cities have experienced multiple extreme floods since 1995; a consequence of prolonged heavy rains. Southern Africa has experienced a significant increase of flooding incidences since 2010 (Decapua, 2011). In South Africa, thirty-three towns across nine municipalities were declared disaster areas in 2012. The most affected households were farm workers, informal settlements and rural villages (Department of Science and Technology South Africa, 2010). In Mozambique, a red alert was declared for the affected river basins of the southern and central regions during the same period (Decapua, 2011). This flooding was a consequence of La Nina. La Nina is a climatic phenomenon that is the opposite of the warm El Nino events, which are believed to bring about droughts in Sub-Saharan Africa (Red Cross et al., 2012). Once La Nina events are predicted, they typically last for a year or two, peaking during the October-January period (Red Cross et al., 2012). This coincides with most of southern Africa’s rainy season, usually resulting in excessive rainfall during these periods (Red Cross et al., 2012). In 2011, the rains resulting from the last La Nina event were predicted to last beyond May of 2011 and subsequently resulted in floods.

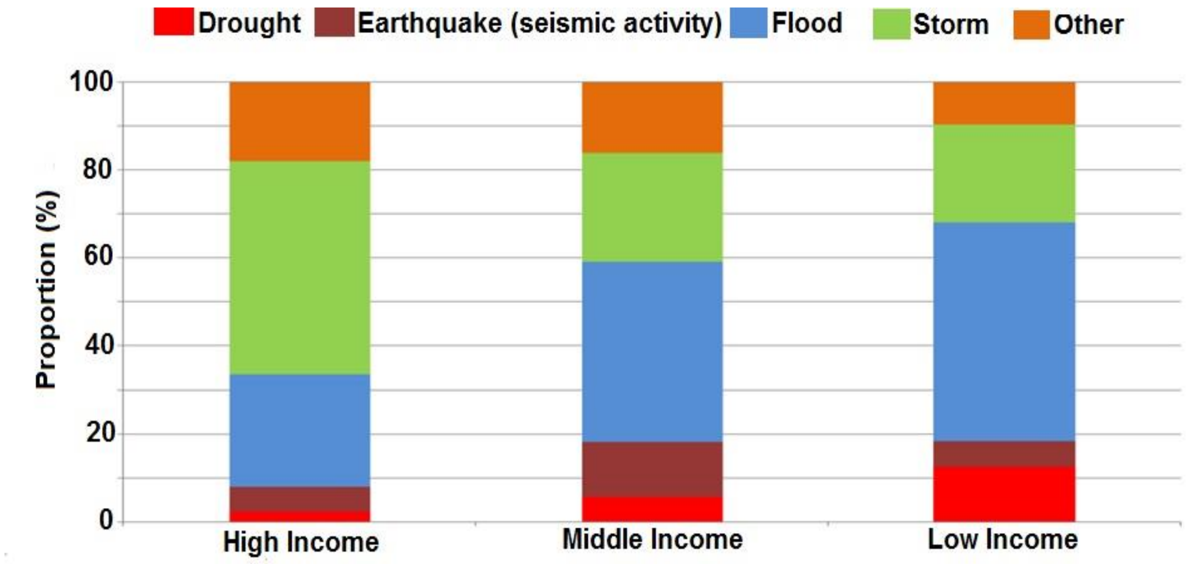


**Figure 1.1:** Distribution of disaster types by levels of economies 1961-2010 ( Source: Guha-Sapir & Hoyois, 2012).

In South Africa, many people lost their homes due to the floods, and over ZAR2 billion in damages to crops had already been realised by January 2011 (NASA, 2011). In late 2012, however, much of the Eastern Cape province had received over 100 % of its normal monthly rainfall according to the South African weather service data (Figure 1.2), resulting in floods (South African Weather Service, 2013). South Africa falls in the category of 16-60 floods from 1974-2003 according to the CRED (in Poolman, 2008). Between 1984 and 1988, only nine floods occurred in the Southern African Development Community (SADC) region, but between 1999 and 2003, this number had jumped to 59. South Africa’s general hazard analysis shows that between 1961 and 2005, floods accounted for 39 % of all hazards, making floods the most frequent disaster type in South Africa. Severe storms are the second most frequent at 22 % (Poolman, 2008; Douglas et al., 2008). A breakdown of disaster occurrence by province for the same period showed that most of the flooding occurred in the Western Cape, whereas the Eastern Cape experienced the most severe storms (Poolman, 2008).

The impact of disasters as reported by the CRED (in Poolman, 2008) showed that floods caused the most loss of homes and economic damage relative to all the other disasters (Prevention Web, 2013). In 2012, economic losses and damage were estimated to be more than ZAR1 billion. The damage realised was a consequence of the week long heavy rains along with subsequent flooding in late October 2012 in the Eastern Cape (Anon, 2012c).

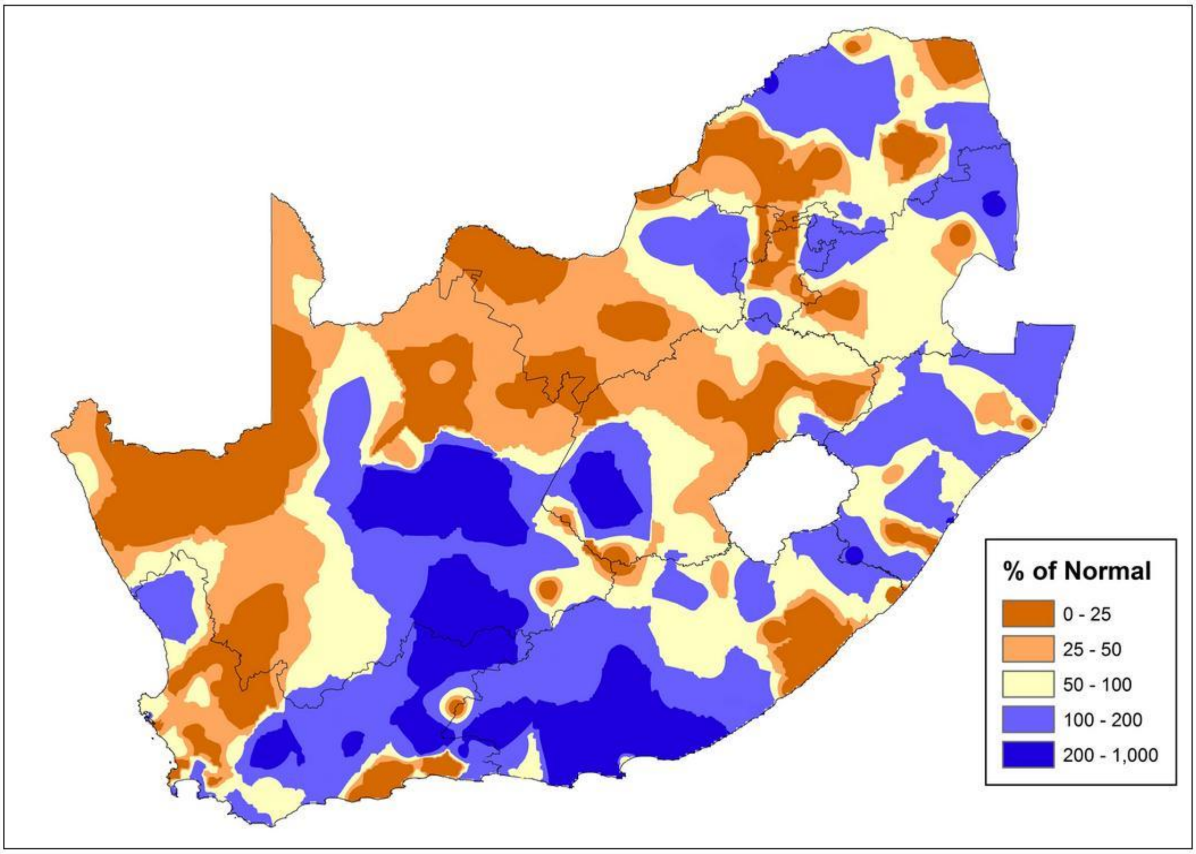


**Figure 1.2:** Percentage of normal rainfall for October 2012 (Source: South African Weather Service, 2013).

Thunderstorms are a serious problem in South Africa as they are relatively short-lived but at the same time can produce heavy downpours (Poolman, 2008). Storms also have a short lead time and this increases the danger of being caught unprepared. In February 2000, the Limpopo Province was affected by severe flooding that resulted in 84 people losing their lives, and also in the destruction of road infrastructure worth over ZAR1 billion. More than 300 000 people were left homeless after 45 000 traditional dwellings were damaged (Khandlhela & May, 2006). Many areas in Limpopo Province were subsequently declared disaster zones. In February 2009, Soweto in Gauteng province experienced severe flooding as a consequence of thunderstorms in which two people lost their lives (Jennings, 2011). Prior to this, George, in the Western Cape had suffered severe flooding, with the most affected areas being concentrated in the low-cost settlement areas (Benjamin, 2008).

South Africa generally experiences four types of flooding, namely coastal flooding, river flooding, flash flooding and pooling or rising flooding. The Eastern Cape is mostly plagued by flash flooding for which it is generally more difficult to predict and develop warning systems (Benjamin, 2008). This is characteristic of the frontal weather systems that are prevalent in the area which are embedded with sudden periods of heavy rainfall, resulting in the biggest flooding problem in South Africa in terms of scale (Anon, 2012c).

#### *1.2.1.1 Flooding in the Eastern Cape in 2012*

In October 2012, Port Elizabeth in the Eastern Cape experienced flooding when rising waters in the Swartkops River burst the banks (Anon, 2012c). The National Sea Rescue Institute (NSRI) rescued 76 people and a dog in Port Elizabeth during the same flooding period (Anon, 2012d). Rains in other parts of the province also resulted in the N2 highway being closed to traffic when a huge hole about 25 m wide and 50 m deep developed in the road between Port Elizabeth and Grahamstown (Anon, 2012a). The Sand River Bridge between Cape St Francis and St Francis Bay was also washed away due to the heavy rains. Dozens of people had to be evacuated from flooded informal settlements in Nelson Mandela Bay (Anon, 2012b). It was also reported that the stormy weather patterns in the Eastern Cape claimed 11 lives and over 2 000 people had to be moved from their flooded homes in the Nelson Mandela Bay Metro with damage worth millions of Rand having been realised (Schoeman, 2012). Almost 400 mm of rain were recorded over six days in Port Alfred (equivalent to ± 80 % of total annual rainfall), where a number of streets and houses were flooded, and almost 300 mm of rain was recorded in Port Elizabeth over the same period (equivalent to ± 65 % of total annual rainfall) (Capazorio, 2012; South African Weather Service, 2013). In Port Elizabeth, the Brickmakerskloof Bridge was washed away. The combined flow of the Groot and Gamtoos Rivers was 742 $m^3s^{-1}$ during the time of the downpours (Schoeman, 2012). The Kouga reservoir was ≈108 % full and overflow over the wall was flowing at 627 $m^3s^{-1}$ (Schoeman, 2012). Low-cost settlement areas in the Eastern Cape were affected, including areas surrounding East London, as well as Port Alfred and Port St. Johns. These areas were declared disaster areas by the government of South Africa (New24, 21 April 2013).

Grahamstown was also no exception to the flooding and was amongst the most affected towns in the Eastern Cape. Students at Rhodes University waddled through knee high waters as Prince Alfred Street was flooded (du Toit, 2012). According to Lang (2012), the Sun City informal settlement in Grahamstown was severely affected by the heavy downpour of rains in late October 2012. The areas that were most affected, however, were the Phaphamani and Zolani informal settlements. Residents in the area experienced torrents of muddy water gushing into their homes from interleading walkways in the settlements. Corrugated iron walls were penetrated with flood waters whilst roofs were seeping rainwater.

## 1.3 Governmental institutional responses to flooding in South Africa

The Disaster Management Act No. 57 of 2002 (DMA), emphasises the importance of prevention and mitigation of risks in South Africa. To this effect, it stipulates that all district municipalities must have a disaster management committee/centre, while local municipalities must have a disaster officer. In spite of the preventative mandate of the DMA, however, emergency relief efforts are the typical responses to disaster in South Africa (Zuma et al., 2012). Disaster management has been largely uncoordinated, and has focused on remedial action after an event, and not on preventative measures (Viljoen & Booysen, 2006). It is therefore necessary for appropriate studies to advocate for approaches that focus on reducing flooding risks, a necessity this research aims to help fulfil (Viljoen & Booysen, 2006). The Department of Science and Technology South Africa (2010) shows that the Eastern Cape province has the highest number of people living in poverty and increasing levels of vulnerability, ushering in a socio-economic context to the distribution of natural disasters to the South African disaster scenario.

## 1.4 Causes and consequences of flooding

According to Poolman (2008), the main natural cause of flooding in the Eastern Cape province is due to heavy downpours from the intensive storms that plague the area. The flood risk, however, is increased by anthropogenic activities such as land use patterns and degradation of the natural environment. The combination of land use patterns and a degrading natural environment with intensive rainfall can result in increased incidences and impacts of flooding. Nel et al. (2014) argued that many of the anticipated increased occurances of natural hazards are not only a consequnce of climate change, but rather of rapid and widespread land cover change and the subsequent loss of the buffering capacity provided by healthy ecosystems against natural hazards.

### 1.4.1 Land use patterns and their relationship to flooding

Suriya & Mudgal (2012) showed how the rapid increase in population and the change in land use patterns in the Thirusoolam sub-watershed (SE India) were the major reasons for the occurrence of flooding. Agricultural land cover was found to have decreased from 24 % in 1976 to 15 % in 2005. This coincided with an approximate 17 % average increase in peak discharges in the sub-watershed. Urban development and corresponding land use patterns reduce the available area of effective floodplain, causing streams to increase in cross-sectional area by 2–3 times as a consequence of alluvium deposition, making them flood (Nanson & Young, 1981). Kazmierczak & Cavan (2011) investigated surface water flooding risk to urban households in greater Manchester (UK) and also analysed the spatial associations between hazard, vulnerability and exposure and found that materially deprived households were particularly at high risk to flooding due to a convergence of factors related to socio-economic charateristics, the spatial distribution of the hazard, land use and housing types in the area. They also investigated the various housing and land use types focusing on the presence of vegetation as components of exposure to surface water flooding; an approach this research has also adopted. Kazmierczak & Cavan (2011) found that households that were surrounded by mostly pavement were more exposed to flooding compared to those surrounded by vegetated areas.

Urbanisation alters the natural route of flood waters by covering large areas of the ground with impermeable surfaces such as roofs, roads and pavements. The increase in crowding in urban areas has been observed to impact surfaces and drainage (Douglas et al., 2008). Indeed, even a moderate storm now produces high flows in rivers and high surface run-off. Water that flows through culverts and concrete is not able to adjust to changes in the frequency of heavy rainfall as well as natural streams do. An intense thunderstorm, which generally occurs once every two years in urban areas in Africa, can deposit as much as 90 mm of rain in 30 minutes (Douglas et al., 2008; Nel et al., 2014). The volume of run-off produced by impervious surfaces overwhelms culverts such that localised flash flooding occurs, often within a small area of impact. Such flash floods, quite like those experienced in the Eastern Cape, happen suddenly, move rapidly and violently, resulting in high threat to human health and safety and severe damage to property and infrastructure (Benjamin, 2008).They are more susceptible to blockage by silt, debris and rubbish, especially where shelters are built in close proximity to the channels. The urban poor are are doubly affected therefore as local authorities attempt to mitigate the impact of flooding, they usually prioritise main administrative town areas (Douglas et al., 2008). As many informal settlements develop in areas not designated for human dwelling, such as Alexandra in Johannesburg, which is in a floodplain, they are excluded by the local authories, and at times, may have waters diverted towards them by drainage sturctures (Douglas et al., 2008).

### 1.4.2 The role of land use change in exacerbating incidence and intensity of flooding in South Africa

In South Africa, rapid and unmanaged urbanisation is thought to have increased flood susceptibility especially in townships and informal settlements (Benjamin, 2008). Flood risk has increased due to the removal of vegetation, alteration of soil properties and increased debris flow which compromises drainage systems (Benjamin, 2008). The growth in urban populations particularly in flood prone river basins, is thought to be the reason accounting for the increase in flooding incidents in southern Africa and South Africa (Poolman, 2008). Furthermore, unplanned and unmanaged developments in informal settlements limit government’s ability to mitigate and manage flooding as these areas typically lack in proper service provision and infrastructure (Douglas et al., 2008). Disaster management in South Africa is therefore increasingly becoming a priority for the national, provincial and local governments.

## 1.5 Ecosystem services, disservices and natural resource role in coping and adaptation to flooding

According to Wisner et al. (2004 p.16), ‘the natural environment presents humankind with a range of opportunities (resources for production, places to live and work and carry out livelihoods) as well as a range of potential hazards…flood plains provide ‘cheap’ flat land for businesses and housing; the slopes of volcanoes are generally very fertile for agriculture; poor people can only afford to live in slum settlements in unsafe ravines and on low-lying land within or around the cities where they work’. The opportunities referred to above can simply be called ecosystem services, whilst the unsafe ravines can be areas most likely to experience ecosystem disservices (Lyytimaki et al., 2008).

The distribution of these services and disservices shows a spatial variety inherent in nature (Bryne et al., 2008; Lyytimaki et al., 2008; Sudmeier-Rieux et al., 2013). There is, however, another bias to the distribution of services and disservices. In the quote above, a social, economic and political dimension to the distribution of these services and disservices is apparent (Alcamo & Bennet, 2003). Humans are not equally capable of accessing the resources and opportunities (also known as ecosystem services) that are provided by nature; and neither are they equally exposed to the hazards, or disservices (Alcamo et al., 2003). This is a consequence of social, economic and political processes which underlie many environmental injustices internationally. These processes render others more at risk to disservices such as floods, and more vulnerable to the impacts of these disservices due to a lack of coping mechanisms and resources for mitigation and recovery (Robbins, 2004).

### 1.5.1 Vegetation cover in flood disaster mitigation

Land use and land management have greatly affected the hydrology that determines flood hazards (Wheater & Evans, 2009). According to the Conservation Fund (2013), flooding in the United States of America in recent years has caused an average of US$6 billion a year in property damage. They also claim that the consequence of shrinking forests and wetlands is a one in 10 year storm having the ability to cause as much runoff as a 25 year storm. Increasing forest cover in the long term reduces flows due to increased evapotranspiration and infiltration, thus reducing flood hazards (Bosch & Hewlett, 1982). Historical narratives with regards to flow reduction established in the 1800s used runoff coefficients to account for different land use and land covers (Legg et al., 1996). Runoff coefficients used in this calculation assign forested ground a value of near 0, whereas pavement is given values close to 100. Mostaghimi et al. (1994) provided a runoff coefficient of 0.05 for forest cover, while Legg et al. (1996) and Pitt (1987) gave a runoff coefficient for B soils (granular cohesionless soils including: angular gravel similar to crushed rock, silt, silt loam, sandy loam and, in some cases, silty clay loam) and sandy clay loam and C soils (granular soils including gravel, sand, and loamy sand) as 0.10 for turf cover. A regression of 40 sites in the USA measured by Schueler (1987) gave a runoff coefficient of 0.95 for impervious cover.

It is well established that forests act as sponges for rainfall and produces very little if any stormwater runoff at all (US Forestry Service, 2008). Forest monitoring in North America has shown that less than 5 % of rainfall falling on a forest is converted into runoff (runoff coefficient) (Cappiella et al., 2005). Vegetation cover, and forests in particular, are seen to be the most sustainable means to managing storm water as they can serve several purposes all at once. It was found that residential front gardens in households in the UK significantly reduced surface runoff (Cameron et al., 2012). Perry and Nawaz (2008) found the 13 % increase in impervious surfaces over 30 years in the city of Leeds (UK), 75 % of which was a consequence of paving of front gardens, was linked to more frequent and severe flooding in the area (Kithiia & Lyth, 2011).

Trees and natural vegetation provide various ecosystem services such as provisioning and cultural services (Chomitz & Kumari, 1998). They also provide regulatory ecosystem services, one of which is flood regulation and mitigation (Keating, 2002). It is for this reason that maintaining natural vegetation has been used in stormwater management which includes wooded wetlands, tree check dams, linear stormwater tree pits, stormwater dry ponds, alternating side slope plantings, multi-zone filter strips, forested filter strips and bio-retention and bio-infiltration (McCuen & Moglen; Cappiella et al., 2005; The Conservation Fund, 2013). Vegetated strips or buffers are effective in reducing storm water run-off into streams as well reducing the amount of eroded sediment that is removed from agricultural land resulting in reduced soil deposition in streams (Bureau of Watershed Management, 2006).

Undisturbed vegetative cover during land development is also a more cost effective approach in stormwater management compared to the engineering approach (Adams, 2008; Kithiia et al., 2011). This is referred to as ‘green infrastructure’. Green infrastructure uses vegetation and soil to manage rainwater where it falls. The presence of trees slows down and temporarily stores runoff which in turn promotes infiltration, decreasing flooding and erosion downstream (McPherson, 1998; Giupponi et al., 2014). North American municipalities are now incorporating stormwater management practices that conserve forests and incorporate vegetative features (ASLA, 2006; Tree Trust et al., 2007). By incorporating these natural processes into the built environment, green infrastructure has the potential to not only perform stormwater management, but also to assist in flood mitigation (Wheater & Evans, 2009). Green infrastructure has been seen as a resilient and affordable solution that meets several environmental and conservation objectives all at once based on its use in the USA, and has the potential to do the same in poor countries and poor communities in South Africa (The Conservation Fund, 2013). For the urban poor of developing countries, this may as well be the most cost-effective solution to the flooding problem in the near future, as often, governments can be unwilling to provide the informal settlements with integrated drainage systems, which are seen as being outside the stipulated urban regulation and planning systems (Douglas et al., 2008).

Studies on the role of natural resources acting as physical barriers that mitigate the impacts of flooding are concentrated in North America and in the UK (The Conservation Fund, 2013; US Forestry Service, 2008). In Australia, studies have been concentrated in floodplains, and mostly investigate the effects of riparian zones along stream or river banks (Warner, 1992; Bren, 1993; Bacon et al., 1993). Other studies conducted in Australia have also investigated land use change from forest land into urban landscapes with a focus on river channels (Gregory et al., 1992; Huang & Nanson, 1997), and more recently, on planning and flood risk management (Scott et al., 2013). Most work in South Africa has concentrated in developing assessment methodologies of resilience and vulnerability (Viljoen et al., 2001; Hay et al., 2012; Stuart-Hill & Schulze, 2012), and also on developing ways to predict floods (du Plessis, 2002; Lennard et al., 2013) and effective warning systems. There therefore exists a gap in knowledge on how natural resources can mitigate the physical impacts of flooding in South Africa, more so in the Eastern Cape province, as the use of vegetation cover as physical mitigation to flooding is yet to be established at a household level in the Eastern Cape province.

### 1.5.2 Natural resource role as daily net, safety net and insurance

In vulnerable households, the use of natural resources as income substitutes and coping mechanisms is common (Shackleton & Shackleton, 2004; Davenport et al., 2012). Khandlhela & May (2006) examined poverty, vulnerability and the impact of the February 2000 floods in the Limpopo Province, five months after the floods occurred and found that one of the main impacts was changes in income. It was found that in Limpopo, there was no commercial agriculture in the area, but the informal economy consisted of selling firewood and thatching grass (Khandlhela & May, 2006). Of the 531 household members in the survey, only 153 people reported having an income. This therefore hints towards a high reliance on the natural environment for income and subsistence, which can increase after a flood. Dependence on and use of natural resources has been categorised by Shackleton & Shackleton (2004) as daily nets and safety or emergency nets. Such natural resources include any biological resource collected from the wild by rural and urban households for direct consumption or income generation on a small scale (Davenport et al., 2012).

These natural resources either serve a regulatory purpose, as a ‘daily net’, or as a fall-back in times of need, as a ‘safety/ emergency net’.The daily net function of natural resources represents a cost saving to households, and indeed even to the state. The daily net function allows for the accumulation of savings as it substitutes income. Shackleton & Shackleton (2004) found that rural households in South Africa harvested an approximate annual average of 5.3 tonnes of fuelwood, 58 kg of wild spinaches, 104 kg of edible fruits and 185 large poles for fencing, kraals and houses. The mean gross, direct-use value across the 14 South African studies was ZAR3 854±786 per household per year (equivalent to ZAR7 000 p.a in 2013) (Shackleton & Shackleton, 2004). As cummulative values for income substitution, this can be a significant contribution to income. For example, when in Makana Municipality in the Eastern Cape, 23 % of households earn less than the poverty line of R800 per month (Department of Science and Techonlogy South Africa, 2010; Makana Municipality, 2011). Whilst the natural resources meet the daily household needs, this allows the households to use their limited cash resources to secure other household needs and to endeavour to accumulate the much needed asset base for a more secure livelihood, such as educating children, or accumulating agricultural capital. It also cannot be ignored that this cost saving benefit on a household does also indeed spill over onto a national level by the provision of food, shelter, energy and medicine, in the absence of which the state would ultimately have to provide (Shackleton & Shackleton, 2004). It is for this very reason that the role that natural resources play in easing poverty and providing additional options for income generation cannot be ignored or trivialised.

Natural resources can also assist households with coping in times of difficulties that manifest as sudden changes in the economic, social or bio-physical environments within which households exist and function. In a study investigating the role of non-timber forest products (NTFPs) in Dyala and Dixie in the Eastern Cape province, Paumgarten & Shackleton (2011) found that 8 % of the households sold NTFPs as a safety net, stating that trade as a form of safety net greatly depends on market accesibility. The sale of forest products can occur on a regular basis, seasonally as a gap filler or in times of emergency as a safety net (McSweeney, 2004; 2005). The sale of NTFPs is particularly important for most vulnerable and marginalised segements of society, and in South Africa, has been used by especially rural households to cope with setbacks, with females being the most invloved in the trade (Shackleton et al., 2008). Natural resources therefore become a coping strategy, playing a ‘safety net’ role in times of misfortune (Shackleton & Shackleton, 2004). This role may take three forms:

i. Types or species of natural resources being used that had not typically been used by the household prior to the misfortune, such as the collection of poles for building instead of purchasing commercial building poles.
ii. Increased use or consumption of natural resources that are used, which typically involves the substitution of purchased commodities with harvested ones, such a decline of household use of paraffin offset by the increased use of fuel wood.
iii. Transitory or temporary sale of natural resources on local and regional markets such as road side fuel wood vending, reed mat vending or wood carving.

The direct-use value of the natural resources used during adversity does not adequately show their true value, as it does not account for the emergency insurance component of use during hard times.

The informal occupations and income streams that poor people are involved in can rarely be said to provide a sustainable livelihood or a way out of poverty except for the minority. There is indeed mixed evidence on the effectiveness of informal safety nets, and it can be said that they can only be potentially useful in small to medium shocks, but are often inadequate in response to larger shocks (Paumgarten & Shackleton, 2011). Shackleton & Shackleton (2004) found that most households engaging in the trade of natural resources remain poor, have inadequate assets and are unable to meet all their aspirations. Shackleton et al. (2008) points to a key debate in the narrative of natural products; whether or not their trade can effectively assist in improving livelihoods and income, or whether or not it offers very limited options and merely serving as a last resort and possibly contributing to the persistence of poverty. Indeed Wunder et al. (2014) did a global-comparative study on the provision of forest products as safety nets to shock and gap filling and found that forest extraction responses to shocks ranked much lower than other common alternatives, and also found a similar result with seasonal gap-filling. Many live on a day-to-day subsistence basis and continue to be vulnerable. Challenges to the sustainability of these livelihoods can be summarised as being greatly variable due to flactuations of the market sizes and prices, seasonal flactuations in the availability of natural resources, issues of access, limited ability and knowhow of natural resource trade (Shackleton & Shackleton, 2004; Shackleton et al., 2008). Poor households also do not have access to credit facilities (Green, 2008).

The high levels of dependency on natural resources of poor households in South Africa, especially in the rural areas, exacerbates their vulnerability to flooding. In the rural areas of Limpopo, it was found that 79 % of the population lives in traditional dwellings that have thatched roofs and walls constructed from sun-baked bricks or wattle-and-mud daub (Khandlhela & May, 2006). Such houses are vulnerable to the impacts of flooding, and after the February 2000 floods, 81 % of the households had lost their huts in the floods (Khandlhela & May 2006). The loss was found to be correlated to the type of materials used for the walls. These findings are similar to those found by Kazmierczak & Cavan (2011), who found that in Greater Manchester, UK, housing type exacerbated vulnerability to flood damage, as light weight constructions were found to be more easily damaged. Similarly, housing quality was a major determinant of flooding damage in Nigeria (Ajibade et al. 2014) and damage during landslides in Pakistan (Rahman et al. 2014). Commonly the elderly live in the most poorly maintained houses, rendering them even more vulnerable. A characteristic of the Eastern Cape, is the out migration of the 25-40 age groups into the large metropolitan cities leaving behind the very young and the very old (Makana Municipality, 2011). These populations are even more vulnerable to flooding, and possess little resilience to disasters. The challenge becomes how to make natural resources more sustainable in vulnerable livelihoods, and specific to this study, to establish the role that natural resources play in coping and adaptation strategies to floods of vulnerable populations in the Eastern Cape.

## 1.6 Conceptualising risk and vulnerability

The concept of vulnerability has been used as an analytical tool to describe states of susceptibility to harm, powerlessness and marginality of both physical and social systems (Wisner et al., 2004). It has also been used to guide analysis of actions to enhance well-being through the reduction of risk (Adger, 2006). This concept was adopted into this study to investigate the state of physical exposure and livelihood vulnerability to flooding of the study population. The key parameters of vulnerability are the stress to which a system is exposed, its sensitivity and its adaptive capacity (Adger, 2006). Risk can be defined as the combination of hazard, vulnerability and exposure. In turn, vulnerability is the result of the interactions between physical characteristics (susceptibility) and the capacities of the socio-economic system to adapt and cope with a given hazard. Exposure quantifies the natural and anthropogenic assets, which may be subject to the hazard (Giupponi et al., 2014), whereas hazard by definition refers to the likelihood of occurrence within a specified temporal period and area of potentially damaging phenomena (Pramojanee et al., 2001).

The vulnerability framework of Blaikie et al. (1994) divides vulnerability into three main components: exposure, resistance and resilience. Exposure is conceptualised within the context of flooding as the product of the physical location and the nature of the surrounding built and natural environment. Resistance becomes the economic, psychological and physical health and the system of preservation that represents the capacity of an individual or group of people to endure the impact of a hazard. This can be simply summarised as:

$$V=f\{E(A);S(A)\}$$

where, V is vulnerability, as defined above; E is exposure (exogenous variable) which is the likelihood of the human system being affected by a natural event, or climate stimulus; S is sensitivity (endogenous) which is the degree to which a system would be affected by the exposure; and A denotes adaptive capacity which is the ability of human systems to adjust to actual or expected changes (Hogarth et al., 2014).

Hogarth et al. (2014) suggest that the vulnerability of humans can also be a factor of the endogenous characteristics of the human system, whether it is a household, community or a nation. The capacity of human systems to adapt can be limited by structural and historical factors (Hogarth et al., 2014). Human systems' ability to cope varies according to local climate stimuli within a range with upper and lower thresholds which are dynamic in nature in response to both exogenous and endogenous factors interplaying within the system. A system's adaptive capacity therefore refers to its ability to enlarge or shift its coping range in response to variations in the climate, such as fluctuations in the frequency or magnitude of extreme events (Hogarth et al., 2014). Thus, the product is resilience to a hazard; which is the ability of an individual or a group to cope with or adapt to hazard or the capacity to resist and recover from disaster losses (Lei et al., 2014).

In the context of social-ecological systems, which are in essence the mutual and dynamic interaction of the societal (human) and ecological (biophysical) subsystems (Gallopin, 2006), resilience refers to the magnitude of disturbance that can be absorbed before a system changes to a drastically different state as well as the capacity to self-organise and the capacity for adaptation to developing circumstances (Adger, 2006). Resilience is a product of the extent of planned preparation embarked upon towards the anticipation of a potential hazard, and of spur-of-the-moment or deliberate adjustments made in response to an experience of a hazard. This includes relief and rescue efforts. The vulnerability paradigm is closely linked to the Sustainable Livelihood Framework (SLF) (Pelling, 2003). This framework was used in this study.

## 1.7 The sustainable livelihood framework

The SLF emerged in 1999, with its foundation in previous work by Chambers and Conway (1992), Carny (1998) and Scones (1998). Pioneered by Chambers and Conway (1992) through a framework that emphasised the enrichment of capabilities, equity and social sustainability, it also borrows from the Urban Vulnerability Framework by Moser (1998). Its roots can also be traced back to the work of Sen (1981). The SLF also emerged from the concept of 'sustainable development', and has since evolved into more participatory approaches to embrace the complexity and diversity of the livelihoods of the poor and better comprehend the local realities in which they exist (McDermott, 2006).

There is a clear relation between vulnerability and livelihoods (Benjamin, 2008). This is because similar components that constitute vulnerability also constitute livelihoods. A livelihood is understood as the capabilities, assets and activities that are required for a means of living (McDermott, 2006). A livelihood is considered sustainable when it is able to cope with and recover from stresses and shocks and maintain or enhance its capabilities, assets and activities both in the present and future without undermining the natural resource base (McDermott, 2006; Benjamin, 2008). The sustainable livelihood approach is often used to define the objectives, scope, and priorities for development activities. It aims to formulate development that is people-centred, responsive and participatory, multilevel, conducted in partnership with the public and private sectors, dynamic and sustainable (Serrat, 2008).

The SLF helps to organise the factors that constrain or enhance livelihood opportunities and shows their interactions and relationships (Serrat, 2008). The SLF is made up of five main components: the livelihood asset pentagon, the vulnerability context, the transforming structures and processes, livelihood strategies and livelihood outcomes (Figure 1.3).

The asset pentagon comprises of five types of capital from which households draw to construct their livelihoods (McDermott, 2006) namely:

i. **Natural Capital –** The natural resource base, ecosystem goods and services used in livelihoods.

ii. **Social Capital –** The social networks, affiliations, relationships and access to broader institutions.

iii. **Human Capital –** The education, skill sets, and ability to work to pursue livelihood strategies.

iv. **Physical Capital –** The basic infrastructure and means of production equipment which allow people to pursue their livelihoods.

v. **Financial Capital –** The sources of cash, savings and credit available to households

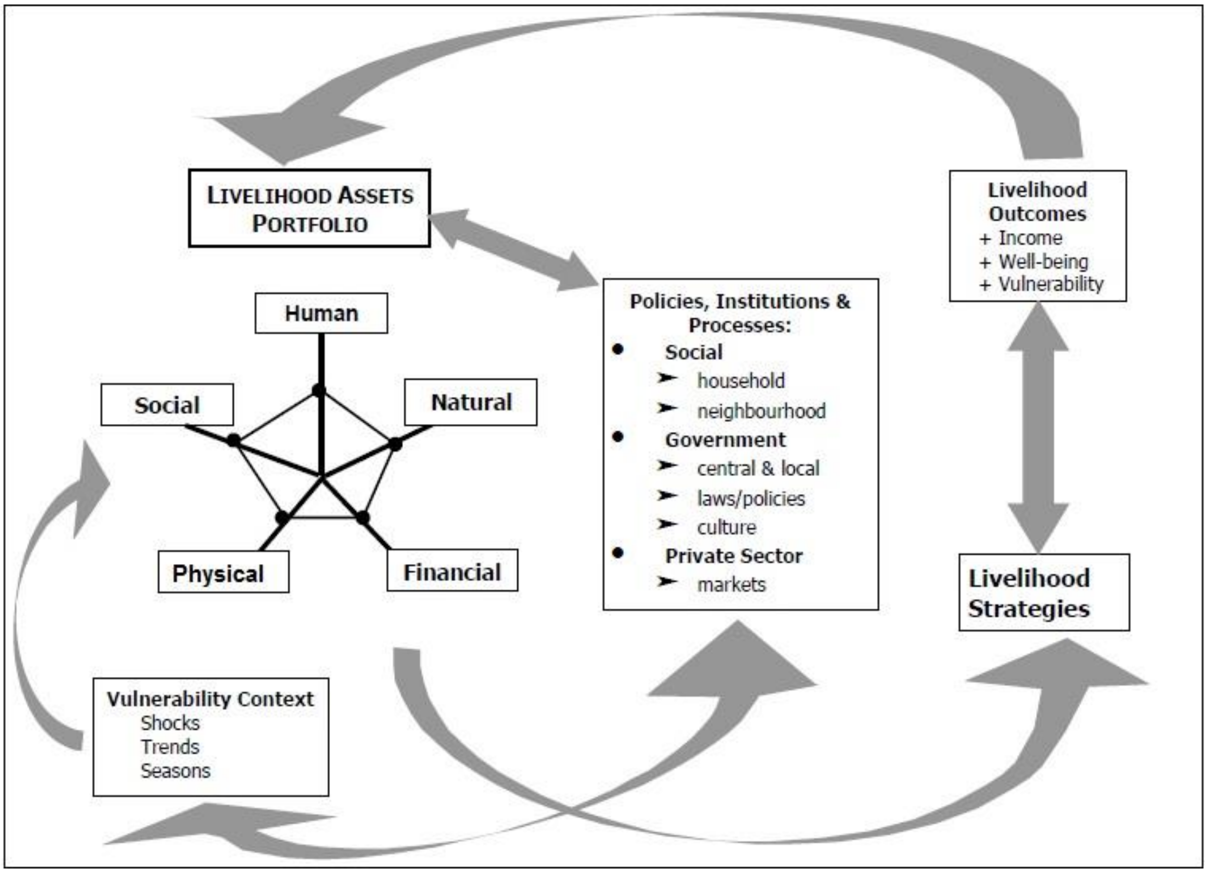


**Figure 1.3**: The sustainable livelihood framework. (Source: Majale, 2001).

## 1.8 Natural disasters and livelihoods

Hoffman & Oliver-Smith (2002), Robbins (2004) and Dellink & Ruijs (2008), all plausibly infer that socio-economic contexts can more often than not be a stronger determinant of livelihood loss than the actual physical occurrence of a disaster event. This claim is strongly supported by evidence in Guha-Sapir & Hoyois (2012) of Cyclone Nargisin that occurred in 2008 which killed more than 80 000 people in Myanmar alone, in spite of it having also swept through Eastern India and Bangladesh. The reasons given for this are that Myanmar lacked the advanced warning systems that other places had, leaving the people in the Ayerwaddy Delta trapped. The area was also difficult to access for humanitarian personnel. Furthermore, the area was densely populated. It is thus apparent that the reason why cyclone Nargisin was more of a disaster for Myanmar than all the other areas is a socio-economic one (Robbins, 2004). This is echoed at household level, with richer households being better able to pre-empty and respond to disasters, as observed in floods in Lagos (Nigeria) (Ajibade et al. 2014).

Wisner et al. (2004) and World Bank et al. (2011a) advocate that micro level studies are necessary to show the impacts of disasters on livelihoods. Evidence produced from a recent study on floods in Orissa (India) showed that educating mothers on the risks of malnutrition during flood periods can effectively protect children from chronic malnutrition at a far reduced cost (Wisner et al., 2004). Such evidence of the impact of a disaster on an aspect of livelihood can only be observed on a micro-scale over a longer period of time (Robbins, 2004).

There is therefore a need for more micro-level studies to be conducted to identify the factors that determine the impacts of specific disasters so that effective response strategies and policy can be developed. Not only should such micro-level studies be carried out at the time of disaster, but also after the disaster because some of the impacts may be more significant in the medium and long term than has been previously assumed (World Bank, 2011b). This research identifies the problem of macro-scale data and the absence of information on the impact of flooding on the livelihoods of vulnerable households in the Eastern Cape, and the role that natural resources play in recovering the losses of livelihood that they experienced. This information is of great importance in the future planning of relief actions and preparedness actions for households, communities and the state.

Indeed, disasters suffered in Africa take a greater toll on livelihoods, rendering them more vulnerable and exacerbating the condition of the ‘risk society’ (Wisner et al., 2004; Lorencova et al., 2013). The 2011 famine on the Horn of Africa led to the displacement of over ten million people (Paul, 2011). Previous disaster impact assessments therefore often appear to fail to account for the human impact that affect poor people; and especially the impact on their livelihoods. Although, according to EM-DAT Africa does suffer from less massive disasters, the mortality and morbidity brought about by large scale disasters is greatly underestimated, rendering it unimportant to policy and priority in the region (Guha-Sapir & Hoyois, 2012). This is because the bulk of studies within the disaster paradigm are done at a macro-level, and therefore do not possess the necessary magnifying lens needed to assess impacts on livelihoods (Wisner et al., 2004; Rice, 2007). Not to mention, that data reporting post disaster is still comparatively and relatively weak on the African continent (World Bank, 2011b). In addition, whilst aggregate numbers and value of economic losses maybe lower, the impacts on individual households afflicted are no less severe or traumatic for them.

The effect of large-scale disasters such as droughts, and even smaller scale disasters such as floods, on natural resources, ecosystem services and livelihoods is still greatly under researched in Africa (World Bank, 2011a). Shackleton et al. (2010) argue that there are knock-on effects that have been overlooked such as the level of direct and indirect damage on natural resources that result from such disasters. Furthermore, how this affects coping and adaptation, as observed in the Eastern Cape of vulnerable populations, has also been overlooked. According to Guha-Sapir et al. (2012), these knock-on or indirect effects of disasters are only recently being discussed in global policy fora in addition to the more direct and immediate effects. The problem, however, is that systematic data or studies monitoring these effects on coping and adaptation using natural resources are still hard to come by; a problem this research aims to address.

### 1.8.1 Climate change adaptation, risk and vulnerability

It is becoming progressively clearer that mostly in Less Economically Developed Countries (LDCs), vulnerable people often suffer multiple, recurring and mutually reinforcing and often simultaneous shocks (Dellink & Ruijs, 2008). According to Shackleton et al. (2010), these shocks have a tendency to diminish whatever attempts the households would have made to amass any form of livelihood security. In this way, these shocks affect the manner and degrees of coping and adaptation, and indeed, the resilience of households to disaster. This research aims to depict patterns of coping and adaptive design within vulnerable households of the Eastern Cape that were affected by the recent floods and relate these to their use of natural resources as a safety net. Although research has been done before in the area of adaptation of vulnerable populations to shocks by Wisner et al. (2004), there is not much research that quantifies natural resources in the coping and adaptation process post disaster. Therefore, this research adds another element to the knowledge already established.

Wisner et al. (2004) suggest that in developing countries, there exists a ‘risk society’; a group of people naturally more exposed to the detrimental impacts of ecosystem disservices. Ironically, efforts made by such risk societies to provide some sort of security against shocks and disturbances that are a consequence of climate change often create even more risks (Lorencova et al., 2013). This phenomenon is often referred to as maladaptation. Wisner et al. (2004) provides evidence of forested land in the Honduras and Nicaragua that was cleared for the purposes of agriculture to boost exports and develop the economy and better the lives of the citizens. This effort benefited a few; but further endangered many others, the already vulnerable, to hurricane Mitch in 1998. The heavy rains caused massive landslides on the denudated slopes which destroyed villages and towns. Thus, efforts to reduce economic vulnerability backfired and resulted in increased exposure to the forces of nature (Foley et al., 2005; Aubrecht et al., 2011; Carse, 2012). This research investigates the possible existence of this phenomenon in the Eastern Cape by investigating patterns of land and natural resource use and availability and linking this to risk and vulnerability.

The capacity of national governments and their infrastructure play a vital role in determining the effectiveness of response and preparedness to and prevention of natural disasters such as flooding (Green, 2008; Aubrecht et al., 2011). Floods can very well be controlled and the impacts thereof buffered and better managed. Zoning regulations and flood-basin management are such institutional and mechanical tools used by wealthier countries to protect people from the devastating consequences of flooding (Carse, 2012). However, in poorer countries, the lack of insurance and infrastructure leaves populations vulnerable to massive disruption in livelihoods (Paul, 2011). Furthermore, a pre-existing state of lack acts to reinforce the impacts of floods on livelihoods. This state of lack and under development has therefore pointed towards natural resources as being potentially a common and sustainable way for developing countries to cope with and to mitigate flood disasters (Green, 2008).

The weak economic situations that are faced by some people force them to inhabit locations that are naturally more prone to natural hazards such as flood plains, dry areas and steep slopes (Robbins, 2004; Rahman et al. 2014). In South Africa, historical imbalances in land and opportunity distribution resulting from the apartheid legacy meant that the poor African populations were placed in homelands lacking in opportunities for development (Hoffman & Oliver-Smith, 2002; Green, 2008; Africa, 2010). This rural malaise in South Africa is a possible cause of the rapid urbanisation in recent years due to rural-urban migration, and as such, has subsequently created another form of vulnerability in the urban areas in the form of informal settlements (Hunter and Posel, 2012). These areas generally lack in service provision and infrastructure, making them high risk areas to natural disasters such as floods (Steyn, 2010).

There are also other somewhat hidden factors that underlie the impacts of hazards. As suggested by Green (2008) and Wisner et al. (2010), these factors may involve the various ways in which assets and income are distributed in different social groups, and even the discrimination inherent in the processes of welfare distribution, not excluding disaster relief – an element that this research will also investigate. The physical losses experienced by the populations in this study will have an impact on their well-being and livelihoods. However, the economic and social ties such as kinship in their lives may help to buffer such losses (Dellink & Ruijs, 2008; Ajibade et al. 2014). For instance, farming may help to reduce the impact of the flood losses. Trade may also have the same effect (Shackleton et al., 2011). The effect of the flooding disaster on these buffers will also be assessed, and in addition, the use of natural resources to buffer both economic and physical losses will also be investigated. This study will therefore attempt to assess vulnerability in three dimensions; the first is ‘social vulnerability’ of the populations, then the ‘economic vulnerability’ and finally the ‘physical vulnerability’ (Wisner et al., 2004).

## 1.9 Problem statement

Climate change has brought about increases in the incidences and intensities of flooding (Yuen & Asfaw, 2011). Furthermore, the perpetual state of risk and vulnerability of poor people in the Eastern Cape is being compounded by these disasters, specifically the most recent flooding shock that hit the area during the period October 2012-February 2013 (Africa, 2010; News24,10 April 2013). Whilst there is an increase in the incidence of disasters such as flooding, there is a decrease in the ability of vegetation cover to mitigate the potential risk and severity of impact of disasters in the Eastern Cape (Foley et al., 2005; Giupponi et al., 2014). This is a consequence of land use patterns and an increasing dependence on natural resources by the vulnerable households. Additionally, problems of natural resource availability, accessibility, neglect and degradation which compromises resilience, especially to natural shocks like floods, also affect the roles of vegetation cover and natural resources in mitigating natural disasters for vulnerable populations in the Eastern Cape (Shackleton et al., 2010; Giupponi et al., 2014). This also compromises the ability of the populations to adapt to climate change.

There is a lack of understanding on how natural resources contribute to resilience of vulnerable populations in the Eastern Cape and how they are impacted by these populations before, during and after a flood shock. Better understanding on how the vulnerable organise themselves to better cope during flood recovery by incorporating natural resources and how this affects resilience is needed. This understanding will possibly result in natural resources being prioritised in disaster risk reduction for the vulnerable in South Africa and be incorporated into disaster recovery management/programmes. This will also could prompt better management of natural resources in the Eastern Cape.

## 1.10 Aim and objectives

### 10.1.1 Aim

The aim of the study was to improve understanding on how natural resources contribute to the resilience of vulnerable populations in the Eastern Cape to natural shocks such as floods

### 1.10.2 Objectives and key questions

1. **To establish the strategies that households use to recover from flood shocks**
    1.1 What aspects of their assets and livelihoods were affected by the recent flooding shock?

1.2 What short-term and long-term efforts or steps did people take to cope and adapt to the flooding shock?

2. **To quantify and evaluate the relative contribution of natural resources to the recovery strategies**
   2.1 Was there evidence of households using natural resources to cope and adapt to flood shocks?
   2.2 Which resources were being used, how and to what extent?
   2.3 What affected or determined the way in which these resources were used?
3. **To establish if and how patterns of land cover types and household topographical location exacerbate or diminish physical impacts of flooding**
   3.1 Were there any apparent differences in the types of land cover that can be related to the differences in the severity of damage to land or property?
   3.2 Did the topographic position of the homestead and its proximity to water bodies influence the physical impact of the flood to land and property?

# CHAPTER 2. STUDY AREA AND METHODS

“Water: Too much… Too little… A leading cause of… disasters…” *Domeisen, 1997: in title*

**Plate 2.** Informal settlement next to a wetland dominated by *Phragmatis* sp. is flooded during October 2012. (Source: www.citypress.co.za)

## 2.1 Chapter overview

This chapter describes the components of the hazard risk, vulnerability and damage loss assessment methods. It links these methods to an assessment of recovery and capacity (which infers coping and adaptation within the general context of this study) and provides a description of the study areas. All these methods of assessment collectively inform the sustainable livelihood framework and the concepts of vulnerability within which this research is synthesised. The methods used for the purposes of this study take into account specifically the role of natural resources in influencing the capacity of the 'hazardscape' (referring to the physical attributes of the landscape on which the flooding hazard occurred) and household vulnerability to flooding. It also describes the study area on which this study was conducted.

Using methodological triangulation that drew from both primary and secondary sources of information, an assessment of capacity (to cope or absorb and adapt to the hazard) was carried out at two scales; the macro (settlement) scale and the micro (household) scale. Triangulation was therefore used to assess the level of household flood vulnerability, coping and adaptation strategies that were taken in response to both the 'hazardscape' vulnerability. These were related to the role of natural resources and ecosystem services. This chapter provides a description of the methods used in collecting and synthesising the data for the research.

## 2.2 Introduction

Guha-Sapir et al. (2012) and the World Bank (2011a, b) both observed that in the past, the assessment of disaster impacts was incoherent at several levels. More often than not, information would be collected at the time of the emergency by varying service providers using whatever tools were available at the time. Data collection was rushed due to the time pressures to respond quickly for fund raising or relief planning and this was detrimental to data quality (World Bank, 2011b). Furthermore, data collection methods were never standardised or systematic, because differing data collection agencies used varying terms and definitions. Ultimately, the data that were collected in the past could not be compared either across zones or over time. Impacts of interventions thus became difficult to assess (World Bank, 2011a). It was therefore necessary to develop a baseline methodology.

The year 1972 saw the beginning of efforts to develop standardised methods of disaster assessment. One of the most common methodologies now being used as a result of these efforts is the Damage and Loss Assessment (DaLA) methodology. The DaLA was initially developed by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC) in 1972. It has since been further developed and has been used collaboratively by the World Health Organisation (WHO), World Bank, International Labour Organisation (ILO), United Nations Educational Scientific and Cultural Organisation (UNESCO) and other organisations to capture the closest approximation of damage and losses due to disaster events (World Bank, 2011a).

The method typically uses a government's national accounts and statistics as the baseline data to assess damage and loss. The methodology does, however, factor in the impact of disasters on individual livelihoods and incomes by the use of loss functions. Instead of simply assessing the value and the extent of the losses in monetary terms, a relative impact index is calculated by weighing monetary losses by either household incomes or the value of household possessions. This index is more reflective of actual and intangible damage including livelihood damage (Viljoen et al., 2001). This entails triangulation of qualitative and quantitative data analysis approaches. This helps to define the needs for recovery and reconstruction, and also to determine the optimal set of flood control or mitigation measures for a flood area (Viljoen et al., 2001). This research used the DaLA methodology as far as it helps to assess damage and loss to livelihoods post disaster (World Bank, 2011b). This research added an element to this methodology by relating damage, loss and recovery to the role of natural resources and ecosystem services in the livelihoods of flood affected households in the Eastern Cape.

Another method used within disaster management and livelihoods is the Disaster Needs Analysis (DNA), seemingly derived from the DaLA methodology. This method was developed by the Assessment Capacities Project (ACAPS), which is an initiative of a consortium of three NGOs that works "to mitigate the impact of natural disasters and complex emergencies through the provision of effective humanitarian responses" (ACAPS, 2013). To achieve this, ACAPS developed innovative needs assessment tools and methodologies. This particular methodology typically involves the use of various sources to conduct a predominantly desktop qualitative research, with a smaller quantitative aspect.

Purposive sampling is used as the dominant sampling method for both secondary and primary sources of information while conducting the DNA (ACAPS, 2013). Thought-through samples are considered to be of more value than those that are in essence, more statistically representative (Babbie, 2011; Bryman, 2012; ACAPS, 2013). Units of analysis, such as individuals selected for questionnaires, are chosen according to pre-knowledge from primary documents that profile the individuals. This helps researchers to acquire much more information from a smaller sample such that it becomes more relevant to a broader population (ACAPS, 2013). Although not necessarily statistically representative in the typical sense, it is far more qualitatively generalizable. Therefore, the basis of the sample selected for questionnaires was based on the analysis of documents relating to the population being studied.

This research adopted elements of the DNA methodology in that most of the review of literature was done prior and simultaneously with the questionnaire. A similar approach was also used in a post-flood study conducted in Limpopo province, where a small sample of 70 was used for structured household interviews conducted between two study areas; 35 in each (Khandlhela & May, 2006). The secondary sources that are relevant to this methodology are population based national representative sample surveys, the demographic and health (or livelihood) survey, and national census and multiple indicator cluster sample surveys done by UNICEF (ACAPS, 2013). This study therefore used a host of documents, namely newspaper articles, reports and photographs to give an understanding of the context. This was done so as to be able to purposively sample a smaller but qualitatively rich sample for the study as the more prior information is available, the better the selected sample. A variety of sources were therefore sourced to ensure the reliability of the sources, and questionnaires were also carried out so as to ensure the validity of the data from the primary documents.

Furthermore, the DNA methodology considers research that is done more than two weeks but no more than ten years from the time of the disaster to be more relevant to deciphering implications on the livelihoods of the affected populations that those done within two weeks of the disaster (ACAPS, 2013). This justifies the time period within which this study was conducted as it aims to decipher how natural resources and ecosystem services contribute to the livelihood resilience of vulnerable populations in the Eastern Cape to natural shocks by studying the October 2012 flood event. The pitfall of this method, is however, that although the primary documents that are usually available post disasters can inform on where the data were collected, they do not necessarily inform on how the data were collected which can possibly negatively impact the quality and reliability of the data.

This research employed methodological triangulation via document analysis and questionnaires (Fowler, 2002). It was conducted in two overlapping phases. Primary and secondary document analysis were the primary qualitative approaches employed in the study, whilst questionnaires and mapping in ArcGIS were the key quantitative approaches of data collection used (Babbie, 2011). The qualitative data were then thematically analysed, whilst the quantitative data were analysed with descriptive and inferential statistics using

Statistica (StataCorp, 2011), SigmaPlot (SigmaPlot, 2006) and PC-ORD (McCune & Mefford, 2006).

The bio-physical data were analysed using ArcGIS and then thematically analysed by adding data from the statistical analysis of the questionnaire data. This approach was also used by Kazmierczak & Cavan (2011), which combined primary document analysis with ArcGIS. The study, which was conducted in the greater Manchester area, UK, revealed the percentage of the areas that are most susceptible to flooding by overlaying datasets showing the areas that were most susceptible to surface water flooding as they related to land use, vegetation type and geomophological charactersitics together with datasets showing demographic characteristics that indicated vulnerability. The results suggested a strong link between topography, land use and poverty (Kazmierczak & Cavan, 2011; Kithiia & Lyth, 2011). Indeed Giupponi et al. (2014) suggest that intergrating the physical-environmental dimension and socio-economic factors in assessing risk whilst considering the role of adapative and coping capacities in reducing risks and related costs is a valuable approach in assessing capacity and risk of societies to water related hazards.

## 2.3 Study area

This study was conducted in three small towns in the Eastern Cape, South Africa, which were affected by the October 2012 floods (Figure 2.1), namely Grahamstown, Port St. Johns and Port Alfred.

### 2.3.1 Grahamstown

#### *2.3.1.1 Makana Municipality*

Grahamstown is the seat of the Makana Municipality. Grahamstown is approximately 55 km from the coast, at a height of 535 m above sea level (Makana Municipality, 2011), at 33.30°S, 26.53°E. Grahamstown receives an average rainfall of 715 mm per year, with average temperatures ranging from 9.8 ºC to 23.1 ºC (South African Weather Service, 2013). The Makana Municipality has a total population estimated at 80 390, of which 78 % are black African, with a growth rate of 0.7 % per annum. The Makana Municipality forms part of the Cacadu District Municipality. The Makana Municipality is situated almost mid-way between of Port Elizabeth (to the east) and East London (to the west) on the N2 highway (Statistics South Africa, 2011; Rhodes University, 2013).

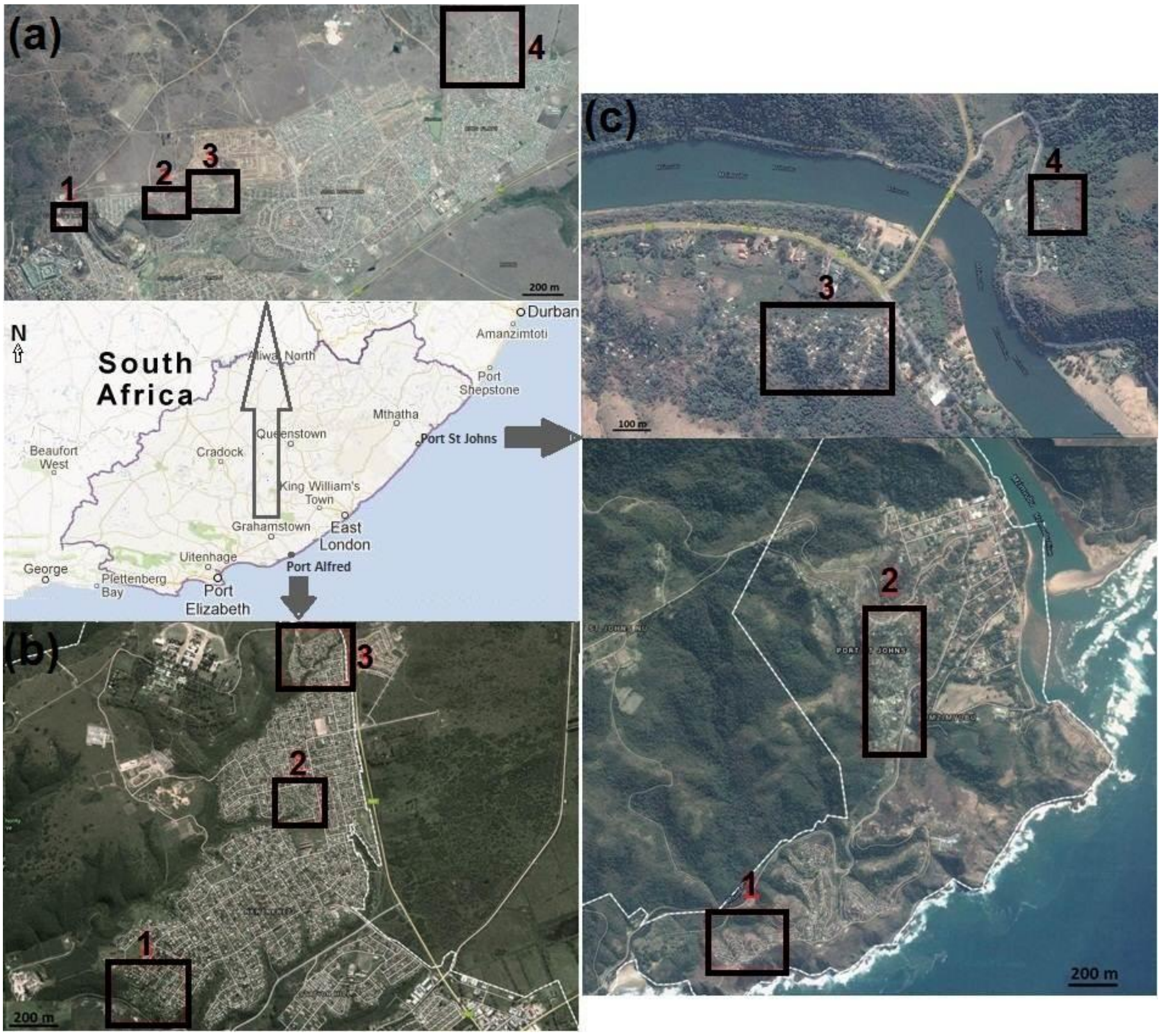


**Figure 2.1**: Location of informal settlements sampled in each of the 3 towns: (***a***) **Grahamstown**: *1* – Sun City, *2* – Polar Park, *3* – Phaphamani, and *4* – Zolani. (***b***) **Port Alfred**: *1* – Biso, *2* – Cricket Park and *3* – New Rest. (***c***) **Port St Johns**: *1* – Gapiri, *2* – Green Farm, *3* – Tiger Flats and *4* – Sikilikili.

Makana has five biomes, namely Albany thicket, fynbos, grassland, nama-karoo and savanna. Grahamstown has a mixture of 12 vegetation types including Bhisho thornveld, Great Fish thicket, Kowie thicket and Albany broken veld which were dominant in the study area (SANBI, 2013). Key demographic data on Makana, including Grahamstown, are highlighted in Table 1.1.

**Table 1.1**: Key demographic statistics, Makana, Port St Johns and Ndlambe Municipalities, Eastern Cape, 2011. (Source: Statistics South Africa 2011).

| **Key Statistics** | **Makana** | **Port St Johns** | **Ndlambe** |
|---|---|---|---|
| Total population | 80 390 | 156 136 | 61 176 |
| Number of households | 21 388 | 31 715 | 19 331 |
| Young (0-14) (%) | 24.4 | 42.5 | 25.2 |
| Average household size (people) | 3.4 | 4.5 | 3 |
| Working Age (15-64) (%) | 69.4 | 51.8 | 64.8 |
| Elderly (65+) (%) | 6.2 | 5.6 | 9.9 |
| Dependency ratio (%) | 44.1 | 92.9 | 54.3 |
| Growth rate (per annum 2001-2011 period) (%) | 0.7 | 0.6 | 1.12 |
| Population density (persons/ km$^2$) | 18 | 121 | 33 |
| Unemployment rate (%) | 32.5 | 50.3 | 30.3 |
| Youth unemployment rate (%) | 42.3 | 61 | 39 |
| No schooling aged 20+ (%) | 6.3 | 23.5 | 9.7 |
| Higher education aged 20+ (%) | 11.9 | 3.9 | 9.9 |
| Matric aged 20+ (%) | 22.7 | 11.9 | 20.1 |
| Female headed households (%) | 44.5 | 60.1 | 42.6 |
| Formal dwellings (%) | 85.4 | 24.6 | 83.6 |
| Housing owned/paying off (%) | 48.3 | 72.9 | 42.3 |
| Flush toilet connected to sewage (%) | 71.9 | 1.9 | 35.5 |
| Weekly refuse removal (%) | 88.9 | 3.1 | 78.5 |
| Piped water inside dwelling (%) | 49.8 | 2.7 | 36.1 |
| Electricity for lighting (%) | 89.5 | 67.8 | 86.3 |

This study focused on households located in the east of Grahamstown, in the informal settlements. Four informal settlements were studied, namely Zolani, Phaphamani, Polar Park and Sun City.

### 2.3.2 Port St Johns

Port St Johns is under the jurisdiction of the OR Tambo District Municipality. It is 90 km east of Umthatha, at 31.63° S, 29.54° E. Port St Johns district is both an inland and coastal urban area that incorporates approximately 130 rural villages. Sixteen wards are covered by the municipal area, of 1 239 km$^2$ (Port St Johns Municipality, 2011). Demographics of Port St Johns are highlighted in Table 1.1.

#### *2.3.2.1. Port St Johns Municipality*

According to Census 2011, the population of Port St Johns municipality comprises 156 136 persons, with a growth rate of 0.6 % per annum. Port St John's forms part of the OR Tambo District Municipality. It is bounded on the eastern side by the Indian Ocean. To the north-east, it is bounded by the Mzintlava River and Ingquza Hill Municipality. It is constituted by one magisterial area, viz. Port St John's. The municipality is largely rural or traditional in character and the main economic activity is subsistence farming and tourism (Statistics South Africa, 2011). The town of Port St Johns is a local service and ecotourism centre. Port St Johns experiences a humid subtropical climate, with an average maximum temperature of 24 °C and an average minimum of 17 °C (South African Weather Service, 2013). It receives an annual average rainfall of 1 096 mm. The vegetation of Port St Johns consists of three biomes namely grassland, Indian Ocean coastal belt and savanna. It has a total of 12 vegetation types, with the dominant type being the Transkei coastal belt, scarp forest, southern mistbelt forest and the mangrove forest being the most common in the study area (SANBI, 2013). This study focused on four informal settlements namely Gapiri, Green Farm, Tiger Flats and Sikilikili.

### 2.3.3 Port Alfred

#### *2.3.3.1. Ndlambe Municipality*

Port Alfred is situated in the Ndlambe Municipality, which has a total population of 61 176, of which 77.7 % are black African, 14.2 % are white, 7.3 % are coloured, and 0.2 % are Indian according to the 2011 national census. The municipality has a growth rate of 1.1 % per annum. The Ndlambe Municipality is a predominantly rural area with agriculture and tourism dominating the economy, with its capital being Port Alfred, at 33°36'S, 26°55'E. Port Alfred has an average maximum temperature of 26 °C and average minimum of 9 °C. It receives an annual average rainfall of about 836 mm (South African Weather Service, 2013). The vegetation of Ndlambe municipality consists of four biomes which are Albany thicket, forest, fynbos and savanna. There are 12 vegetation types within the municipal boundary, with Albany coastal belt and Kowie thicket being the most dominant, and Great Fish thicket as well as Bhisho thornveld also being common (SANBI, 2013). Key demographic data for Ndlambe including Port Alfred, are highlighted in Table 1.1.Three informal settlements were sampled from Port Alfred for the purposes of this study namely Biso, Cricket Park and New Rest.

## 2.4 Sampling approaches

In this study, the units of analysis are the households located in the three selected study areas and primary documents that refer to the flooding incident that occurred in the three study areas between late 2012 and early 2013. This study used two non-probability sampling techniques; purposive sampling and snowball sampling, and one probability sampling technique; stratified random sampling.

Eighteen households were sampled from Sun City. The households were located at an altitude of between 633-648 m above sea level. Eleven households were sampled from Polar Park. These were situated at an altitude of between 641–648 m. From Zolani, a total of 28 households were sampled which were situated between 632–634 m above sea level. Lastly, 26 households situated between 600–618 m above sea level were sampled from Phapamani. The above four settlements are in the east of Grahamstown. Twenty-four households were sampled from Gapiri, which is at a height of 74–84 m above sea level. Green Farm, located between 15–35 m altitude, had a total sample size of 23 households. Twenty-one households were sampled from Tiger Flats and 15 from Sikikili, at a height of 15–59 m and 12–13 m above sea level, respectively. The above four settlements are located in Port St Johns. Thirty-eight households were sampled from Biso, which is situated between 29–42 m above sea level. A total of 23 households were sampled from Cricket Park, with an elevation of between 65–70 m above sea level. The last settlement that was sampled was New Rest, at 73–76 m with a total of nine households sampled. The above three settlements are located in Port Alfred.

### 2.4.1 Purposive sampling

Purposive or judgmental sampling is used to choose a sample on the basis of knowledge of a population and its constituents, and the purpose of the study (Babbie, 2011). This knowledge maybe, for instance, of experts in a particular area (Berg, 2007), and selecting this particular group knowing that they would be the most insightful about the subject area (also known as expert sampling) (Bryman, 2012). Purposive sampling is therefore selecting the units to be observed on the basis of the researcher's own judgment and fore-knowledge (Davies & Mosdell, 2006) with regard to which of the units would be the most useful or representative (Jupp, 2006). It has the limitation that it will not select the most representative sample of the study population. This method was the primary sampling technique to source all data for this study namely primary documents and households for the questionnaire.

### 2.4.2 Snowball sampling

Snowball sampling is when each respondent in a research survey may be asked to suggest other respondents that they know of according to selected criteria or attributes in which the researcher is interested (Somekh & Lewin, 2005), but lacks representivity (Gliner et al., 2009). Snowball sampling involves the researcher applying their knowledge and judgment to identify a suitable individual who meets the researcher's criteria, and then asking this individual to recommend other individuals that they may know who also meet the researcher’s criteria (McNeill & Chapman, 2005). This method is not necessarily credited to be the most effective as far as selecting the most representative samples (Bless et al., 2006). As most primary documents required for this research were mostly unpublished, this method was also used to retrieve as many primary documents as possible.

### 2.4.3 Stratified random sampling

Stratified sampling is a form of systematic sampling utilised by researchers to ensure that all the variation of interest in a population are measured (Fowler, 2002; Bryman, 2012). Members of the population are grouped into relatively homogeneous sub-groups prior to sampling in a process called stratification. The strata must be mutually exclusive with every unit in the population attached to only a single stratum (Somekh & Lewin, 2005; Gomez & Jones, 2010). The different sub-groups are initially determined either systematically or randomly. Random samples are then extracted from each stratum which enhances the representativeness of the sample by reducing sampling error. The advantage of using stratified random sampling is that its resultant mean has less variability than that of a simple random sample of the population. This technique was used to sample the specific households for the questionnaire.

Primary documents were selected on the basis of availability (convenience purposive sampling) and relevance to the themes identified in the study namely; climate change, ecosystem services and disservices, risk, vulnerability, resilience, coping, adaptation, floods and integrated disaster risk reduction. The researcher purposefully searched for primary documents that made specific reference to the flooding shock experienced in the Eastern Cape during the late 2012 to early 2013 period that directly corresponded to the specific study areas that fit the main themes identified in this research. The researcher also asked the initially identified individuals (disaster management officers) and offices such as the local municipality, to be referred to any other agencies or institutions that were involved in flood assistance in the specific study areas that may have primary records of these events.

The geographic population that was affected by the flooding was thus determined by reviewing primary documents. The populations were then divided into homogeneous subgroups by grouping into clusters of households by settlement. Using primary documents, four informal settlements were identified in Grahamstown, three in Port Alfred and four in Port St Johns. These informal settlements formed the stratum as they were mutually exclusive and homogeneous (Figure 2.1). Within the settlements, Google Earth imagery (2012) was then used to identify clusters of households and following this it was used to also identify individual households within each cluster. These individual households were mapped using push pins in Google Earth. Static images from Google Earth were then printed at a scale of 1 cm to 900 m and a 2×2 cm transparent grid was layered onto the clusters and all households within every second box were sampled. The GPS coordinates of each household sampled were then recorded in Microsoft Excel and used to identify homes to interview for the questionnaire (see data collection). In Microsoft Excel, each household coordinate was assigned a numeric code. The RAND() formula was then used to randomly select between 20 and 30 % of the households from each informal settlement in Excel.

## 2.5 Data collection

### 2.5.1 Primary documents

All data were collected between December 2013 and March 2014. Visits were made to the local newspaper offices of the Groccot's Mail, Grahamstown. A total of 17 articles were collected for the period between October 2012 and February 2013. Three Microsoft Powerpoint presentations and four primary reports covering the period between October 2012 and April 2013 were collected from the various disaster management offices and municipal offices. Registers of damage and loss were also acquired, and also logs of donors and volunteers were collected. Aerial photographs showing the study areas were sourced by ordering them online from the Department of National Geo-Spatial Information (NGI) of South Africa and 1:50 000 topography maps covering the study areas were consulted.

### 2.5.2 Questionnaires

A total of 236 households were interviewed for the questionnaire (Appendix), 83 in Grahamstown, 70 in Port Alfred and 83 in Port St Johns. The questionnaire was purposely aimed at interviewing households that were directly exposed to and/or affected by the October 2012 and February 2013 flooding events in the Eastern Cape. It was relatively easy and timeous to locate and conduct the questionnaires in the study area due the sampling technique employed, although some households declined to participate or were not at home and the researcher had to move on to the next households on the sample frame.

In each of the three towns, the disaster manager was first consulted to seek permission to conduct questionnaires in the disaster zones within their jurisdiction, and also verify the accuracy of the locations sampled. A team of four, including the researcher conducted and captured the questionnaires. In the field, sample households were identified by having their GPS coordinates entered into Google maps and a map was generated showing only the households sampled. Questionnaires (Appendix) were only administered to the respondents at their respective homes. The questionnaires targeted household heads, however, a responsible person (e.g. by virtue of being the eldest present at the time of the researcher arriving to conduct the interview) in each of the households was chosen as a respondent if the household head was absent. The questionnaire took no longer than one hour to complete. Visits to households were only done during daytime hours.

The initial and final part of the questionnaire (Appendix) profiled the households' demographic status, with questions that gathered information on household size, employment and education status and sources of income, including casual, full-time and part time employment, as well as social grants including, pensions and old age, disability, foster and child grants. The second part of the questionnaire captured the use of natural resources as daily and safety nets, whilst the third section captured details of patterns of land use. The fourth and fifth sections captured details relating to the type and extent of flooding damage to both assets and income and the means of subsequent recovery including aid received and the natural resources directly used in the process of recovery physically and how these contributed to subsistence and economic recovery of the household.

## 2.6 Data analysis

Thematic analysis was the primary approach used to contextualise and make sense of the qualitative data collected which took the form of primary documents and transcripts from the questionnaires. The aerial photographs and topographical maps were analysed in ArcGIS to give a bio-physical profile of the population being studied (their hazardscape), and further thematically analysed by combining their vulnerability context and damage and loss data collected in the questionnaires in the form of attribute tables to produce a compound map that combined the state of vulnerability within the hazardscape to the socio- economic state of vulnerability thus providing a socio-ecological model of the phenomena under study. The quantitative data from the questionnaires was statistically analysed in Statistica (StataCorp, 2011), SigmaPlot (SigmaPlot, 2006) and PC-ORD (McCune & Mefford, 2006), and then it was related back to the various themes and contexts revealed in the literature as well from the qualitative data gathered in this research.

### 2.6.1 Thematic analysis

Data gathered in the form of disaster reports, registers of damage and loss, newspaper articles and photographs collected for the period between October 2012 and February 2013 were thematically analysed together with data collected in the household questionnaires for the three towns.

Primary and secondary documents were re-read repeatedly to identify relevant themes and issues. In this study, open coding was employed. Open coding involves the reading over of the entire transcripts to get an overall impression and understanding of the text (Baxter & Babbie, 2005; Marczyket al., 2005). Having completed this process, relationships were then established between the identified categories and were grouped into themes.

The researcher prepared a database of the captured information from the 236 questionnaires in Microsoft Excel and grouped these firstly according to town, then settlements. The data were further subdivided into the main themes of the SLF (Hancock, 1998; Du Plooy, 2001; Babbie, 2005). Concepts and ideas based on the data were thus subsequently developed (Du Plooy, 2001; Baxter & Babbie, 2005).

Data were therefore analysed by the researcher constantly writing any themes and common issues that come up in the data, and identifying themes and patterns if and when they emerged (Thomas, 2003; Babbie, 2007). Typologies about behaviours, beliefs and narrative types were developed in the process (Neuman, 2003). Data were organised according to research objectives and themes in the results chapters (Marczyk et al., 2005). New themes were also identified and these were also added to the results chapters (Somekh & Lewin, 2005; Babbie, 2007; Berger, 2011).

### 2.7 Reliability and validity of study

Validity can be said to refer to the extent to which the measures, samples, and designs of a research can lead to valid conclusions and/or valid inferences (Somekh & Lewin, 2005). Thus, validity refers to the extent to which the conclusion within a study would hold for other persons in different places and at different times. There are four main types of validity in research; internal, external, construct and conclusion validity (Alasuutari et al., 2008; Babbie, 2011). The most relevant to this study were internal and conclusion validity.

Internal validity is most applied to qualitative research methods because it is more concerned with getting an in-depth understanding of a specific phenomenon, than it is with the applicability of a theory over a broader spectrum (Somekh & Lewin, 2005; Berg, 2007). Internal validity is concerned with analysing the existence of a causal relationship between elements within a study (Babbie, 2007; Berg, 2007). Internal validity was utilised in determining the credibility of this study due to the qualitative nature of part of this research. Conclusion validity refers to the extent to which a study can conclude the existence of a relationship based on the data collected (Somekh & Lewin, 2005). It is most relevant to inferential statistics which were used to analyse quantitative data in this study (Jackson, 2009).

Several factors can be seen to threaten the validity of a study. These threats can be summarized as people, place, and time (Fowler, 2002; Bryman, 2012). Low reliability of data as a consequence of poor measures and observations is a threat to the validity of a study (Fowler, 2002). These poor measurements and observations are relative to the noise in the study environment. Low statistical power is also a problem in validity. Statistical power can be compromised by the use of an insufficient sample size relative to the population being studied (Fowler, 2002; Gomez & Jones, 2010). Furthermore, the selected measures being implemented to analyse the sample can be unreliable (Thomas, 2003). Perhaps the variability of data collected for the purposes of analysis could be so large that it becomes difficult to observe the relationship of interest (Jackson, 2009), resulting in attempts to establish ‘weak’ relationships (Babbie, 2011). For the above reasons, the researcher took measures to reduce the threats to the validity of study.

To improve the reliability and validity of the study, the researcher ensured that the questionnaire was piloted, worded and organised in a manner that could be easily understood and interpreted for data analysis (Fowler, 2002; Babbie, 2011). Great care was taken in ensuring the accurate recording and retention of all data collected for analysis (Gomez and Jones, 2010). By using primary documents to frame the sampling population, and by using reliable sampling techniques, sampling a sufficiently large sample size (Fowler, 2002; Ruane, 2005), the researcher ensured a representative sample size and effect size.

The primary document analysis also assisted in ensuring that random heterogeneity caused by a diverse group of respondents who can vary the measures and observations was minimised (McNeill & Chapman, 2005). Random irrelevancies in the setting of the questioning were minimised by the researcher taking measures such as asking the respondents to shut the door during the questioning, moving to a private setting for the process of answering of the questionnaire or requesting that other individuals in the household be informed of the process so that they may keep noise levels and disturbances to a minimum (Fowler, 2002). Finally, the researcher adhered to a work plan for the research to ensure good implementation of the project and avoid errors in the research (Gomez & Jones, 2010).

# CHAPTER 3. THE CONTRIBUTION OF NATURAL RESOURCES AND ECOSYSTEM SERVICES TO COPING AND RECOVERY STRATEGIES OF VULNERABLE EASTERN CAPE POPULATIONS TO FLOODING

"The weather is becoming increasingly volatile in Africa." *Commission for Africa*

**Plate 3.** Land slide caused by the October 2012 floods in Port St Johns. (Photo by Tatenda Dalu)

## 3.1 Chapter overview

This chapter presents the results that answer the first two objectives of this study (Section 1.11). It gives a brief description of the study area and population, as well as the methods used to generate the results with reference to Chapter 2. Results of the demographic profile and characteristics of vulnerability of the study population are presented. The various damages and losses from the flood are also reported, as well as the contributions of natural resources. Results of the factors that influence the use or non-use of natural resources are also presented. These results are discussed within the general theoretical framework of this study, and finally, conclusions and recommendations are given.

## 3.2 Introduction

Climate change has brought about changes in the patterns of rainfall distribution and seasonal variations in southern Africa; and the Eastern Cape province of South Africa has been no exception (DST South Africa, 2010). The inhabitants of the Eastern Cape province have therefore had to cope with and adapt to the subsequent shocks and stressors that have been ushered in by climate change. Coping with or to a shock is understood as a shortterm method used by people to buffer or reduce the impact of a shock, whereas adaptation is a longer term strategy which attempts to prevent and/or reduce the occurrence of or mitigate future shocks (Wisner et al., 2004).

Coping and adaptation to climatic shocks, specifically floods, has been studied in other parts of the world, and in South Africa (Hoffman et al., 2002; Khandlhela et al., 2006; Benjamin, 2008). Specific to marginalised and disadvantaged segments of society, the services that the natural environment provides are critical in coping and adapting to shocks. Shackleton et al. (2008), Shackleton & Shackleton (2004), Paumgarten & Shackleton (2011) and McSweeney (2004; 2005) have shown that indeed, the natural environment provides safety nets for the vulnerable during hardships. Great variation in the use of natural resources as well as the contribution to coping, and especially to adaptation, has been observed.

Hoffman & Oliver-Smith (2002), Robbins (2004) and Dellink & Ruijs (2008) all plausibly infer that socio-economic contexts can more often than not be a stronger determinant of livelihood loss than the actual physical occurrence of a disaster event. Specific to marginalised and disadvantaged segments of society, the services that the natural environment provides are critical in the coping and adapting to natural shocks (Paumgarten & Shackleton, 2011; McSweeney, 2004, 2005). Wunder et al. (2014) global comparative study on the use of safety nets showed that 18.2 % of households used natural resources as an initial response mechanism to shock. They also found that 14.2 % used them as a second, and 11.9 % as a third, meaning that 44.3 % used them as a response within a single twelve month period.

The focus of this chapter is on the flooding events that occurred between October 2012 and February 2013 in the Eastern Cape province of South Africa. Specific focus is on informal settlements located in the urban peripheries of three towns namely Grahamstown, Port Alfred and Port St Johns. Within the vulnerability paradigm and the sustainable livelihood framework, the study also quantified and evaluated the relative contribution of natural resources to recovery strategies.

## 3.3 Methods

The study was conducted in three towns in the Eastern Cape Province namely Grahamstown, Port Alfred and Port St Johns. A total of 236 households were interviewed using a questionnaire (Appendix). This is described in greater detail in Chapter two.

### 3.3.1 Data analysis

Variability and normality tests were conducted using the Shapiro-Wilk test. Multiple univariate regression analyses were done using Statistica (StataCorp, 2011) for each of the three towns to determine the relationship between different household variables (income and demographic) and the use of natural resources as coping and adaptation to the flood hazard.

As many variables were collected to depict vulnerability, a principal component analysis (PCA) was carried out to reduce the variables to the most important few. The significance of the identified principle components was later tested in a multiple regression to see whether vulnerability influenced the use of natural resources in recovery. Should the identified principal components match the identified significant variables influencing the use of natural resources in recovery, then it could be concluded that the principal factors influencing vulnerability also affected the ways in which people use natural resources. PCA was used to reduce the questionnaire dataset to ensure against redundancy in the data using PC-ORD version 5.1 (McCune & Mefford, 2006). PCA is a vector space transformation, which assists in the identification of patterns within high-dimensional data, thereby revealing the main factors as principal components (PCs). Through the identification of clustering of variables that measure the same theme, variations with the data are optimally described. Varimax rotation was utilised so as to maximise the variance of loadings thereby aiding the classification of variables to PCs. This data reduction method results in zero correlations between the PCs. Fourteen indicators were initially identified for analysis to be reduced to a small number of PCs. The count data was initially square root transformed so as to normalise the data (McCune & Mefford, 2006). PC-ORD version 5.1 (McCune & Mefford 2006) was used for calculating eigenvectors and variances. Each of these aspects was related to each of the 14 indicators according to which aspect each variable affected. These aspects are access to information, the ability to prepare, respond and recover (Kazmierczak & Cavan, 2011). Access to information has implications on the levels of awareness of the people living in risky spaces, what they can do in response to risk and knowing how to access help in the event of a disaster. Factors such as illiteracy, age and state of mind and inability to understand the local language increase vulnerability (Kazmierczak & Cavan, 2011). The ability to prepare is especially a problem in poor households as they cannot invest in flood insurance or house reinforcements to protect from floods. Female headed households are more vulnerable as they are physically less able to prepare (Wisner et al., 2004). The size of a household, particularly the number of dependencies can compromise the ability of households to respond to flooding, as they find it difficult to move away from danger as there are less resources (Adger, 2006). In informal settlements, emergency services may have difficulty getting to people needing aid due to the overcrowded nature of the settlements and the compromised communication links. The ability of households to recover is affected when marginalised groups in society are overlooked in the development cycle such as the urban poor. They are most in need of additional support in times of disaster, but resources sometimes do not reach them. Pre-existing vulnerabilities such as poverty compromise their ability to recover (Green, 2008).

Means and standard deviations were calculated for damage and loss of property and compared with the housing material used to construct housing structures. The materials used to construct houses as well as the codes used to assess damage are given (Box 3.1). Means and standard deviations were also calculated of the various ways households responded to the floods to see what was the most common.

**Material of house wall**: 1 = mud/soil; 2 = wood; 3 = metal; 4 = brick; 5 = reeds/grasses; 6 = mixed: plastics, boards, wood and metals

**Material of house roof**: 1 = thatch; 2 = wood; 3 = metal; 4 = asbestos tiles; 5=mixed (plastics, boards, wood and metals)

**Physical impact on house**: 0 = nil; 1 = minimal and easy to repair; 2 = moderate and need semi-skilled repair and no part replacement; 3 = above moderately damaged and needs semi-skilled expertise to repair and part replacement; 4 = extreme and repairable with some irreparable damage; 5 = completely destroyed and needs to be totally replaced; 6 = relocated

**Box 3.1**: Material of walls and roofs of houses and level of physical damage on house

Most of the fencing poles, sand and clay as well as sticks and shrubss used in the physical repairs of the damaged homes were either personally and locally collected or sold by small informal traders in the settlement streets. In all instances, only net values were used after deduction of the production costs that are inherent within each income source. In areas of unemployment, the opportunity costs of labour have been disregarded due to the difficulties in identifying relevant shadow prices, and the low opportunity costs in the face of high unemployment. All monetary values are reported in South African Rand (ZAR), at exchange rate approximately USD1 = ZAR10 in 2014. The prices used in the informal trading were used to estimate direct-use values (Thondhlana et al., 2012) (Table 3.1). Furthermore, the number of different livestock types as well as the subsequent goods and services were recorded and valued using local market prices. The value of natural resources used to replace or substitute loss was calculated using local market values where available, otherwise shadow prices were used where a natural resource was replaced by a store bought resource.

The contribution of natural resources to recovery was reported relative to monthly income. This was done so as to show the actual value of natural resources as an *emergency* net and also as natural insurance rather than a *daily* net. To quantify the loss of livelihood, the total loss in monetary values was compared to the total amount of income per annum converted into monetary values in South African Rand (ZAR). This comparison was done per town and per settlement.

**Table 3.1:** Scoring matrix for replacement costs to housing structures per damage extent

| **Extent of Damage** | **Mud** (*ZAR25 per wheelbarrow*) | **Sand** (*ZAR60 per wheelbarrow*) | **Poles** (*ZAR2 per pole*) | **Stick and herbs** (*ZAR30 per bundle*) | **Zinc** (*ZAR52 per 3m$^2$ sheet*) |
|---|---|---|---|---|---|
| 1 (Low) | 125 | 120 | 0 | 30 | 0 |
| 2 | 250 | 240 | 0 | 90 | 0 |
| 3 | 375 | 360 | 42 | 180 | 52 |
| 4 | 500 | 480 | 63 | 240 | 104 |
| 5 (Extreme) | 625 | 600 | 105 | 300 | 156 |

Replacement costs were calculated for each household. As it was found that in most instances, repairs were carried out by the residents themselves, this meant that replacement costs were also excluded the cost of labour due to high unemployment in the study areas. A matrix was developed to calculate the cost of replacement or fixing damage to a housing structure (Table 3.1). Shadow prices and market prices were used to calculate the value of materials needed to fix or completely replace affected housing structures.

The total amount of income and subsistence loss as a direct consequence of the flood was found by calculating the value of means of income and goods destroyed using shadow market prices of the goods lost. These goods varied from vegetables destroyed by the water, to animals that died because of the floods. A cumulative total was then taken for each household's income and subsistence loss. Monthly means and standard deviations of household income including those from casual and informal work as well as the number of income streams available to each household, number of dependents together with income from various grants were calculated.

As differences were noted in the use or non-use of natural resources amongst settlements and likewise amongst towns, multiple regression analysis was used to see which factors determined the use of natural resources in the recovery from floods by the study population. Multiple regression analysis was done for each town.

## 3.4 Results

### 3.4.1 Demographic profiles of the study population

The demographic characteristics of all the sample population in the three towns are presented in Table 3.2. It was found that although Grahamstown had the lowest income and lowest proportion of employed household heads of the three towns; it had the lowest dependency ratio. Grahamstown also had the smallest average household size of 4.9±2.04, with Port Alfred having the largest of 7.1±2.23.

**Table 3.2:** Demographic profiles of study households in Grahamstown, Port Alfred and Port St Johns

| | **Grahamstown** | **Port Alfred** | **Port St Johns** |
|---|---|---|---|
| Number of households interviewed | 83 | 70 | 83 |
| Average household size (people) | 4.9±2.0 | 7.1±2.2 | 6.±1.7 |
| Average number of dependents (n) | 2.5±1.5 | 9.1±2.6 | 7.2±3.2 |
| Number of female headed households | 45 | 36 | 17 |
| Number of households with employed head | 47 | 50 | 54 |
| Average education years of household head (years) | 9.9±2.9 | 9.1±2.6 | 7.2±3.2 |
| Average household annual income(ZAR) | 21 638±15 358 | 24 233±13 708 | 29 419±20 819 |

### 3.4.2 Flood damage and loss relative to income

Grahamstown households' average household income and loss for the four settlements was ZAR57±178 per household (range ZAR 0–1 192).The average household income and subsistence loss for the three settlements in Port Alfred came to ZAR153±371 per household (range ZAR0–2 000). For the four settlements on Port St Johns, the average household income and subsistence loss was to ZAR187±350 per household (range ZAR0–1 750). These amounts also factor in damage and loss to household property (Table 3.3). Relative to the average annual incomes, none of the losses were over 10 % of annual income. Port Alfred settlements collectively suffered the least loss. On the other hand, Tiger Flats and Sikilikili in Port St Johns experienced the highest loss relative to annual income (Table 3.3).

**Table 3.3:** Total and relative livelihood loss (compared with annual income) in informal settlements in the three towns of Grahamstown, Port Alfred and Port St Johns

| Town | n | Mean annual income | Mean income and subsistence loss | Mean replacement cost of housing structure | Relative loss to livelihood (%) |
|---|---|---|---|---|---|
| **Grahamstown** | **83** | **21 638±15 358** | **57±178** | **1 075±552** | **5.2** |
| Zolani | 28 | 20 216±12 066 | 87±244 | 1 026±519 | 5.5 |
| Polar Park | 11 | 12 578±12 066 | 47±125 | 1 090±587 | 8.7 |
| Phaphamani | 26 | 23 345±14 586 | 6±32 | 1 225±589 | 5.3 |
| Sun City | 18 | 20 216±12 066 | 88±203 | 928±516 | 3.8 |
| **Port Alfred** | **70** | **24 233±13 708** | **153±371** | **1 156±535** | **5.4** |
| Biso | 9 | 22 133±17 004 | 222±667 | 1 260±396 | 6.7 |
| Cricket Park | 23 | 27 584±11 481 | 98±251 | 1 035±453 | 4.1 |
| New Rest | 38 | 22 702±14 110 | 171 | 1 206 | 6.1 |
| **Port St Johns** | **83** | **29 419±20 819** | **187±350** | **758±476** | **3.2** |
| Gapiri | 24 | 28 500±22 714 | 48±104 | 883±436 | 3.3 |
| Sikilikili | 23 | 22 640±12 955 | 116±251 | 322±511 | 9.6 |
| Green Farm | 21 | 38 760±24 335 | 363±479 | 978±198 | 1.1 |
| Tiger Flats | 15 | 25 080±16 105 | 279±417 | 919±329 | 9.8 |
| **Sample mean** | **236** | **25 097±16 628** | **132±300** | **996±521** | **4.6** |

The floods predominantly resulted in the damage and loss of houses and animal shelters. These varied with the material from which the roof and walls of housing structure were made. The extent of damage associated with varying housing types for all the three towns are shown in Figure 3.2, which highlights the dominant housing material that was affected by a level 5 damage as a percentage of the total houses made of that housing material. Level 5 represents the highest amount of damage, and therefore represents the highest loss to livelihood economically. It was found that the most affected roofing material was wood, with 67 % of all houses sampled with that roofing type experiencing level 5 damage. The most affected material for walls was reeds/grasses with 100 % of all houses sampled with this walling material experiencing level 5 damage. The least affected housing roof and walling material were thatch and brick (14 % and 8 %, respectively).

In all Grahamstown settlements the mean replacement cost was ZAR1 075±552 per household (range ZAR0–1 786), ZAR1 156±535 (range ZAR0–1 786) for Port Alfred and ZAR758±476 (range ZAR0–1 486) for Port St Johns (Table 3.3).

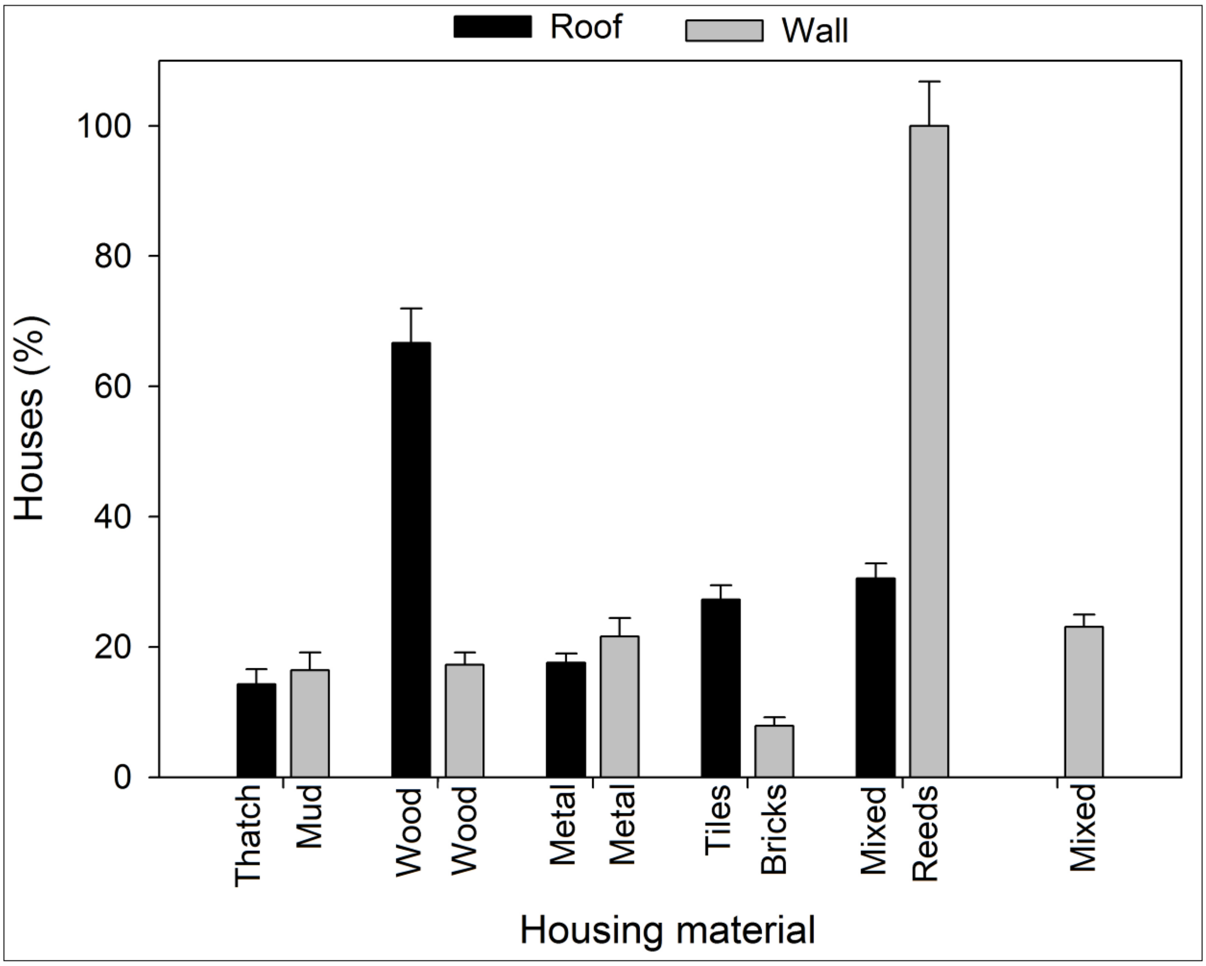


**Figure 3.2:** Incidence of level 5 damage in all three towns according to housing materials for roof and walls.

### 3.4.3 Coping and adaptation strategies used by the population

Four main strategies were evident for coping and adaptation to the flooding shocks in all towns, but to varying extents. Most households reported bailing water out of their house with buckets. Also, during the floods, most homes responded by using stones or blocks and furniture such as wardrobes to prop up their most critical valuables such as television sets from the flood waters. Only five households in this study reported having dug drainage channels to redirect water away from their houses. There was no evidence that suggested any collective efforts at the community level to cope with the flooding by the residents themselves. Rather, 46 % of all households, mostly in Port Alfred, relied on emergency relief which came in various forms from food to blankets, and building supplies in the form of DCP plastic or corrugated zinc sheets from local disaster management offices. Up to 57 % of households in Port St Johns and Port Alfred reported having been temporarily sheltered elsewhere away from their flooded homes, and in other cases, in Port Alfred specifically, this resulted in permanent relocation to new council houses. In all cases, no financial aid was reported to have been received.

Although kinship was also found to be a coping strategy, it was mostly used as labour to assist with repairing the housing structures either with natural resources collected or with the DCP plastic or corrugated zinc sheets provided as emergency aid, especially in female-headed households (Figure 3.3). Most apparent, however, was the use of natural resources as a coping strategy especially for rebuilding and/or reinforcing housing structures, including the use of sand bags to prevent the ingress of water. Natural resources were very rarely used to substitute income or subsistence (Table 3.4).

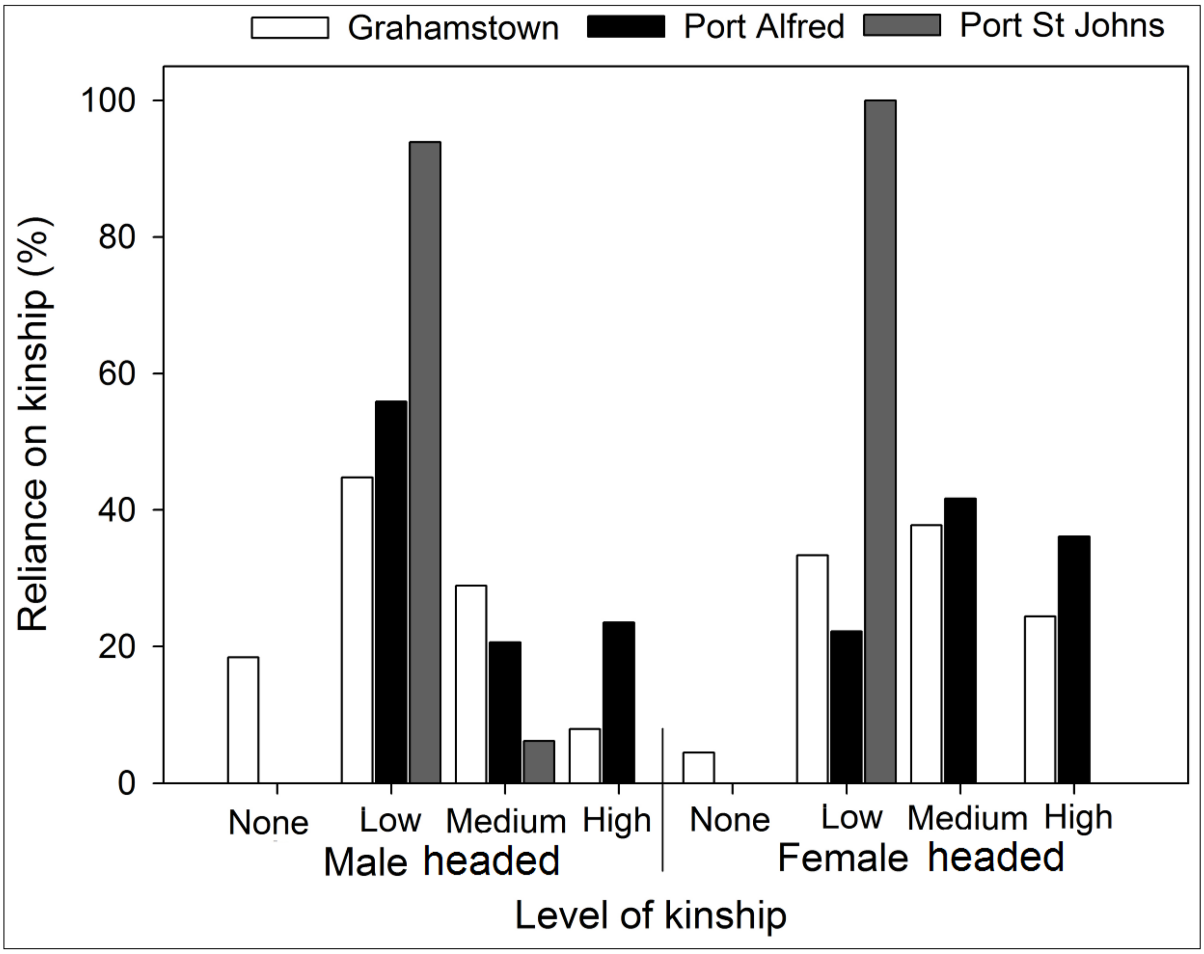


**Figure 3.3**: Level and reliance on kinship of male- and female-headed households as a coping strategy in Grahamstown, Port Alfred and Port St Johns.

**Table 3.4:** Relative contribution of natural resources (compared to monthly income) to recovery of households

| Location | N | Mean contribution to replacement for housing structure (ZAR) | Mean contribution to income and subsistence recovery (ZAR) | Mean combined contribution (ZAR) | Relative contribution (%) |
|---|---|---|---|---|---|
| **Grahamstown** | **83** | **696±669** | **27±132** | **723±696** | **55.2** |
| Zolani | 28 | 650±630 | 35±106 | 686±664 | 53.3 |
| Polar Park | 11 | 1 051±605 | 0 | 1051±605 | 79.3 |
| Phaphamani | 26 | 859±723 | 0 | 859±723 | 56.8 |
| Sun City | 18 | 315±514 | 70±252 | 384±655 | 31.5 |
| **Port Alfred** | **70** | **520±587** | **0** | **520±587** | **46.0** |
| Biso | 9 | 715±699 | 0 | 715±699 | 44.5 |
| Cricket Park | 23 | 635±601 | 0 | 635±600 | 55.6 |
| New Rest | 38 | 404±539 | 0 | 404±539 | 38.1 |
| **Port St Johns** | **83** | **736±586** | **81±273** | **817±683** | **70.3** |
| Gapiri | 24 | 697±636 | 18±88 | 715±650 | 64.3 |
| Sikilikili | 23 | 1 042±359 | 0 | 1 042±359 | 86.5 |
| Green Farm | 23 | 332±580 | 0 | 332±580 | 30.2 |
| Tiger Flats | 21 | 1 003±387 | 300±479 | 1 304±630 | 100 |
| **Sample mean** | **236** | **651±667** | **36±135** | **687±655** | **57.2** |

### 3.4.4 Quantification of the contribution of natural resources to post flood recovery

Natural resources were also found to have significantly contributed to the direct recovery from the flood especially to the rebuilding of damaged housing structures. They were also seen to have contributed to the economic recovery of households, but to a limited extent. Relative to the loss to livelihood that resulted from the floods, it was found that natural resources contributed most to households in Port St Johns with a mean of ZAR817±683 per household amounting to a mean relative contribution to loss of 70 % per household (Table 3.4, Figure 3.4). Port Alfred had the least relative contribution to loss from natural resources of 46 % per household (Table 3.4, Figure 3.4). Grahamstown had a mean contribution of ZAR723±696 per household, amounting to a mean relative contribution to loss of 55 % per household.

### 3.4.5 Characteristics of vulnerability within the study population

The PCA analysis produced four significant axes ($p < 0.01$; axis 1 to 4) which were identified as the significant principle components in the analysis of vulnerability. These four principal components explained a cumulative percentage variance in the data of 54.2 %. Table 3.5 shows the principal component (PC) loadings for the indicators of vulnerability. There are 14 indicators which were taken from the questionnaire.

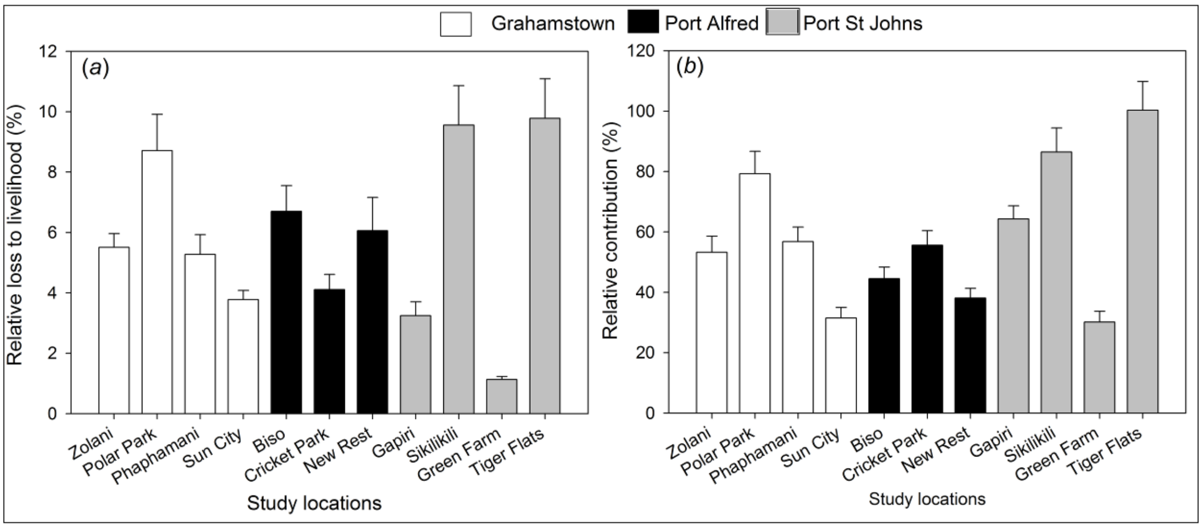


**Figure 3.4:** Relative contribution of natural resources to (*a*) relative loss and (*b*) to recovery of livelihoods by settlement

**Table 3.5:** Principal component (PC) loadings for the indicators of vulnerability. The most significant loadings for each variable are highlighted in bold. Aspects of vulnerability: 1 – access to information; 2 – ability to prepare; 3 – ability to respond and 4 – ability to recover

| **Variables** | **Aspects of vulnerability** | **PC1 Economic** | **PC2 Human** | **PC3 Housing** | **PC4 Stability** |
|---|---|---|---|---|---|
| *Initial eigenvalues* | | *2.85* | *1.98* | *1.52* | *1.25* |
| *Percentage of variance* | | *20.3* | *14.1* | *10.8* | *9.0* |
| Owner of house | 1,2,3,4 | -0.1943 | 0.1969 | 0.4174 | -0.2682 |
| Gender of head | 2,3,4 | **-0.7097** | 0.4543 | -0.2076 | -0.0670 |
| Married/Single | 2,3,4 | **-0.6188** | 0.6196 | -0.0700 | -0.1212 |
| Education level of household | 1,2,3,4 | **-0.4204** | -0.2152 | -0.0364 | -0.2910 |
| Income diversity | 4 | **-0.8275** | -0.2466 | -0.1163 | 0.1948 |
| Employed/Unemployed | 3,4 | **-0.7943** | -0.4275 | -0.1246 | 0.1122 |
| Total income (ZAR) | 2,3,4 | **-0.4616** | -0.0701 | 0.2507 | 0.4019 |
| Years of education of head | 1,2,3,4 | -0.3219 | **-0.6307** | 0.0786 | -0.3313 |
| Number of dependents | 2,3,4 | -0.0546 | **0.4905** | 0.2215 | -0.2925 |
| Level of kinship | 2,3,4 | 0.1724 | **-0.4593** | 0.1748 | 0.3713 |
| Material of house roof | 2,3,4 | -0.1068 | 0.045 | **0.7699** | 0.0093 |
| Material of house walls | 2,3,4 | -0.0863 | -0.0869 | **0.6867** | -0.0399 |
| Number of years in the house | 2,3,4 | 0.0347 | 0.4168 | -0.0092 | **0.6642** |
| Access to NR's | 2,4 | 0.2457 | -0.1485 | -0.2249 | -0.2985 |

The axis were named accordingly as: PC1 – *Economic*, which grouped variables associated with gender of household head, income diversity and total income, marital status of household head, literacy levels of the entire household and employment status, PC2 –

*Human*, which grouped variables associated with years of education of household head, number of dependents and level of kinship, PC3 – *Housing*, which grouped the variables material of roof and walls of the house and PC4 – *Stability*, which singled only the number of years in the house (Table 3.5).

It was found from PC1 that an inverse relationship existed where having a male headed household decreased vulnerability. Vulnerability also decreased with a married household head compared to a single household head (Table 3.5). The education level of the household as a whole also decreased vulnerability. Vulnerability was also found to decrease in households with high income diversity, a higher total income and those with an employed household head. PC2 revealed that the more years of education that the household head possessed, the less vulnerable the household was. A higher level of kinship also reduced vulnerability. It was however found that the more dependents within a household, the more vulnerable the household became. PC3 reported that the type of material used to build the roof and the walls of housing structures increased the vulnerability of households to floods. PC4 also showed that the number of years that a household resided in a housing structure also increased vulnerability to flooding (Table 3.5).

PCs were be linked to the aspects of vulnerability which they most affect. The aspects of vulnerability identified were: 1 – access to information; 2 – ability to prepare; 3 – ability to respond and 4 – ability to recover (Table 3.5). The variable of household ownership did not weigh very heavily in the analysis because very few people actually owned their houses. Some of the variables were also associated with other PCs such as marital status of household head, which weighed more strongly to PC1, but also heavily contributed to PC2. It therefore can be concluded that while the naming of the PCs refers to the principal reasons contributing to vulnerability, a more critical insight into the results given show that these also incorporate secondary aspects (Table 3.5).

### 3.4.6 Factors influencing use of natural resources in recovery efforts

The multiple regressions revealed that in Grahamstown, higher household income resulted in decreasing use of natural resources in recovery, whereas an increase in kinship resulted in an increasing use of natural resources in recovery, accounting for 49 % of the variance (Table 3.6). In Port Alfred, kinship was also found to increase the use of natural resources, as well as the cost of replacing or fixing housing structures. However, it was also found that the greater the physical impact on the housing structure, the less people turned to natural resource, explaining 18 % of the variance (Table 3.6).

**Table 3.6**: Multiple regression results for Grahamstown, Port Alfred and Port St Johns on use of natural resources in recovery. Significant values ($p < 0.05$) are indicated in bold.

| **Factors** | **Grahamstown** | | **Port Alfred** | | **Port St Johns** | |
|---|---|---|---|---|---|---|
| | **t (69)** | ***p*-value** | **t (57)** | ***p*-value** | **t (68)** | ***p*-value** |
| Intercept | -0.800 | 0.426 | 2.132 | **0.037** | 3.500 | **0.001** |
| Physical impact on house | 1.045 | 0.300 | -2.410 | **0.019** | 2.666 | **0.010** |
| Impact on income and subsistence (ZAR) | 0.043 | 0.966 | -0.050 | 0.960 | 0.825 | 0.412 |
| Replacement value of house (ZAR) | -0.56 | 0.577 | 2.359 | **0.022** | 4.447 | **0.000** |
| Relief received (ZAR) | 1.045 | 0.300 | -0.320 | 0.750 | -0.030 | 0.980 |
| Gender of head | 0.852 | 0.397 | 1.034 | 0.306 | 0.646 | 0.520 |
| Married/single | 0.488 | 0.627 | -0.400 | 0.690 | -0.520 | 0.606 |
| Years of education of head | 0.589 | 0.558 | 1.164 | 0.249 | -2.210 | **0.030** |
| Employed/unemployed | -0.810 | 0.422 | -0.580 | 0.564 | 0.989 | 0.326 |
| Income (ZAR) | -2.89 | **0.005** | -0.890 | 0.376 | -1.790 | 0.078 |
| Number of dependents | 0.462 | 0.646 | 0.360 | 0.720 | -0.440 | 0.663 |
| Level of kinship | 4.202 | **0.000** | 2.082 | **0.042** | -1.960 | **0.054** |
| Access to NR's | -1.170 | 0.248 | 0.745 | 0.460 | -0.670 | 0.507 |

***Grahamstown*** *$r^2 = 0.489$, $F_{(13,69)} = 5.077$, std error of estimate: 0.302 (n = 83).* ***Port Alfred*** *$r^2 = 0.179$, $F_{(12,57)} = 1.038$, std error of estimate: 0.397 (n = 70).* ***Port St Johns*** *$r^2 = 0.662$, $F_{(14,68)} = 9.494$, std error of estimate: 0.229 n = 83*

In Port St Johns, with 66 % of the variance, an increase in kinship and in the number of years of education of the household resulted in a decrease in the use of natural resources in recovery. Unlike Port Alfred, however, an increase in physical impact to the housing structure and replacement cost resulted in an increasing use of natural resources (Table 3.6). In all cases however, barriers to use of natural resources did to not have a significant influence on the use of natural resources.

## 3.5 Discussion

### 3.5.1 Aspects of assets and livelihoods affected by recent flooding in relation to vulnerability

Income and subsistence of the households in the study were not greatly affected by the flood. This differed from the findings of Davenport et al. (2012), whose study showed that a proportion of South Africa's urban population rely to some degree on municipal commonage for part of their livelihoods. Commonage contributions to total livelihood incomes ranged between 14 and 20 %. If the contributions from commonage were excluded, the incomes of over 10 % of households in each study town would drop below the poverty line. This was not the case in this study; as even in the cases of unemployment, most households relied on grants. Although grants contributed to the resilience of the affected households by providing financial capital, Davenport et al. (2012), suggests that should the social welfare system in South Africa weaken, the scarcity of alternative means to secure a livelihood (especially in small towns) could lead to a dramatic deterioration in the quality of life of urban poor households.

Indeed, it has been questioned whether or not the extent of the social welfare system has undermined incentives for residents to engage more actively in the informal economy or cultivation of available land resources (Davenport et al. 2012). Shackleton et al. (2008) found in their study that the households receiving pension grants decreased their reliance on the sale of mats for cash. In this study, in terms of household income, a higher proportion of producer and trader households between 45 and 50 % were without a regular source of income, including grants.

Much of the damage and loss realised in the floods were to housing structures, and that the number of years in a housing structure was found to increase vulnerability to flooding. These older housing structures were more vulnerable to flooding damage, as most households could not afford the cost of maintenance, resulting in an increasingly compromised housing structure over time which in turn became increasingly more vulnerable over time to flooding. This was emphasised by the material of housing structures, in which the houses that were made of natural resources had a higher vulnerability to flooding. This can be explained by the fact the most of the housing structures that are made up of natural resources such as mud and sticks are highly sensitive to the elements of weather. Mud houses become structurally weaker with continual alternating extreme heat and cold and damp over time, which causes them to develop cracks (Khandlhela & May, 2006; Benjamin, 2008). Sticks and wood can decompose when exposed to moisture, and are also highly susceptible to attack by insects such as termites. This echoes the results of Khandlhela et al. (2006), where the most common loss in the flood was shelter, and where they found that the loss of housing was correlated to the type of material used for the walls of the housing structure. In their study, 60 % of those that lost their dwellings had used baked mud bricks for walls, and 10 % had walls made of a mixture of reeds and mud, 7 % had walls made of concrete bricks and 4 % made from a mix of mud and cement. For female headed households, this was compounded by the problem of labour to harvest natural resources to repair or maintain housing structures.

Households that had a higher level of dependents were found to be more vulnerable to flooding, and this was consistent with the finding that Port Alfred had the highest relative loss to livelihood and the highest number of dependents of the three towns. This shows that high dependency may have affected the ability of the households to prepare for the flood by depleting fall-back resources, and also that ability to respond to and recover from the shock due to a high demand for resources within the household (Green, 2008).

High levels of kinship and higher levels of education of the household head reduced vulnerability to flooding. Kinship significantly increased the ability of households to recover from flooding thereby reducing vulnerability (McSweeney, 2005; Wunder et al., 2014). Especially for female-headed households, kinship was instrumental in repairing and rebuilding housing structures, thereby assisting in recovery. Closely related to kinship is the marital status of a household head. It was found that in households with married heads, vulnerability to flooding was decreased. All married heads of households were male. The sharing of roles and responsibilities in married households increased the ability of households to prepare for and recover from shocks, as seen in Port St Johns, which had the most number of male headed households, the highest income and the least relative loss to livelihoods. Paumgarten & Shackleton (2011) found in their study that a greater proportion of of poor households relied on kinship in the event of damage or loss of property.

Higher levels of education siginificantly increased the ability of households to prepare for and to respond to the flooding shock. Higher education coincided with employment, which resulted in an availability of money to build houses with bricks which were more resilient to flooding (Wisner et al., 2004; Dellink & Ruijs, 2008; Guha-Sapir & Hoyois, 2012). Higher education and employment also meant that households were less affected economically, as their income streams were frequently unaffected by the flooding. Higher incomes and higher income diversity also reduced the vulnerabilty of households to flooding by increasing the ability of households to respond to and recover from flooding (Green, 2008). In Port St Johns, however, higher employment may be more attributed to the fact that most households were male-headed and most jobs in the area are semi-skilled that it can be attributed to education. Port St Johns had the lowest education years for the household head, it had the highest income and the most number of households with an employed household head.

### 3.5.2 Capacity (coping), natural resources and ecosystem services

Livelihoods in the study settlements were mostly affected by damage and loss to housing structures. Similar to the study conducted by Haque et al. (2014), who found in their study of informal households in Khulna, Bangladesh, that many of the actions taken by households were mostly spontaneous or impact-minimising, and were not necessarily planned or preventive. This may largely be the product of the socio- economic context and associated vulnerabilities of the urban poor. They found that households mostly made modifications to the household dwelling using polythene sheets and empty cement bags, and placing valuable household goods on elevated shelves. Haque et al. (2014) also found, that people turned to natural resources (NR's), specifically bamboo, sand and golpata (nypa leaves) and shrish wood to assist in reconstruction. However, their study did not exclusively quantify the use of these NR's which this study did. In Fiji, it was observed that current adaptation options are mostly hard approaches (up to 80%) which include reinforcing buildings, soft approaches which involved requesting government assistance (up to 85%) an only 6 % ecosystem-based involving planting trees and mangroves (Daigneault & Brown, 2014).

Shackleton et al. (2008) suggested that the socio-economic context and specifically the nature of property rights as well as the degree of underdevelopment and access to markets influences the use of natural resources as a source of income and subsistence and, in the context of this study, as a coping strategy. In Grahamstown, an increase in income resulted in reduced use of natural resources. Income allows for greater household security and provides alternative options for coping to shocks (Dellink & Ruijs, 2008). An increased damage to the house was found to increase the use of natural resources for recovery in Port St Johns. The inverse was true in Port Alfred. Three towns Port St Johns had the most intact natural vegetation, as well the greatest number of houses sampled that were made of mud bricks, reeds and wood. The decreased use of natural resource with increased damage in Port Alfred could be accounted to the emergency relief in the area. The most damaged households were permanently relocated to municipality built houses. The most damaged houses were in most instances those built with natural resources, whereas the other houses with less damage were made of zinc sheets and sometimes brick, in which cases people collected or repaired their zinc sheets, received them from emergency relief or purchased replacements. It was noted in Port Alfred, however, that with an increase in the replacement value of the house, the more households turned to natural resources. In this way, natural resources had an emergency net role in the livelihoods of Port Alfred households. This was also true for households in Port St Johns.

Only in Port St Johns was the education level of the household head found as significant in reducing the use of natural resources as a response to the flooding shock. This is interesting, especially in light of the findings that it had the lowest education level of household heads compared to the other two towns. Educated household heads were less likely to rebuild houses using natural resources as houses made of natural resources in this study, and others such as Khandlhela et al. (2006) were found to be most vulnerable to damage in floods. In this way, educated households moved from coping and response to adaptation and mitigation to future floods. This study also found that indeed, households that had a more educated head were less likely to turn to natural resources as a coping strategy to the flooding shock. Education allows people to compete successfully on the job market, giving them other fall back options in times of hardships (Shackleton et al., 2008).

In all towns, the influence of kinship on natural resource use was found to be significant. In both Grahamstown and Port Alfred, it was found to increase the use of natural resources, whereas kinship was found to decrease the use of natural resources in Port St Johns. This suggests a difference in the ways in which kinship was used; in predominalty female headed households of the former two towns, it was used as labour to harvest resources and assist in repairs. Indeed, it has been found that in shocks that extensively affect communities such as Grahamstown and Port Alfred, people cannot borrow financial resources from each other (Wunder et al., 2014). However, in Port St Johns, the loss from the flood was less extensive in comparison, and this suggests that kinship was used to borrow financial resources for coping for households.

Consistent with the findings of Paumgarten & Shackleton (2011), kinship was found to be significant coping strategy used. Responses in their study suggested that the support from kinship included labour, which was a similar finding of this study. It was also found in this study that kinship was higher in female-headed households, which is also consistent with the findings of Paumgarten & Shackleton (2011), whose study revealed that in coping with damage to/loss of property, 19.4 % of male-headed households turned to kinship compared to 21.4 % of female-headed households turning to the same strategy. Kinship was found to increase the use of natural resources in coping in Grahamstown and Port Alfred, both with a high number of female-headed households, but not in Port St Johns, which had only 17 female-headed households out of 83 households interviewed.

Only in Grahamstown was income significant in reducing the use natural resources as response to the flooding shock. In the other two towns, income showed no significant influence to the use of natural resources for coping and adaptation. This difference may be accounted for by considering the differences between the natural environment of Grahamstown and that of Port St Johns and Port Alfred. Port St Johns has a significantly more intact natural vegetation as did Port Alfred compared to Grahamstown and also the manpower required to make use of the services of the vegetation. Furthermore, Grahamstown had the highest education levels of household heads and also the greatest number of female-headed households; both factors which can discourage the use of natural resources as coping strategies.

The use of natural resources as a coping strategy to damage to or loss of property differs signinficantly from Paumgarten & Shackleton (2011), who found that 28.6 % of female-headed households compared to 5.6 % of male-headed households turned to natural resources. Considering that the least number of households were found to be female-headed in Port St Johns in this study, it was interesting to find that there was a significantly greater contribution from natural resources in recovery (70.3 %) compared to Grahamstown and Port Alfred (55.2 % and 46.0 % respectively). This finding is also in spite of Port St Johns having experienced the least relative loss to livelihood as a result of the flood (3.2 %)

compared to Grahamstown (5.2 %) and Port Alfred (5.4 %), and also having the highest income of the three towns. This suggests a very strong relationship between patterns of land use, the state of the natural vegetation and housing type and location which is discussed in chapter four.

### 4.6 Conclusion and recommendations

Davenport et al. (2012) and Kaoma & Shackleton (2014) concluded in their study that natural resources are a vital resource for the urban poor, notably for energy and construction materials. In this study too, natural resources were found to contribute greatly to reconstruction of shelter. In light of the widespread unemployment and poverty, and evidently, that natural resources from municipal commonages contribute a significant proportion to livelihoods recovery, could not natural resources be considered as a viable means for reducing vulnerability of the urban poor to the impacts of flooding? The consequences of this question are that if the use of natural resources becomes ecologically unsustainable at a particular town, then disaster risk among those resource users would intensify in time (Wisner et al., 2004). Although households in the Eastern Cape used natural resources over and above other livelihood strategies for coping and adaptation to the flooding shock, the sustainable use of these resources needs to be carefully considered. Therefore, the state of natural resources needs to be maintained, so as not to increase the risk of future flooding of urban residents. To do this, disaster management plans need to be developed to incorporate the natural environment and implemented so as to limit the potential unsustainable use of natural resources.

# CHAPTER 4. THE INFLUENCE OF LAND COVER TYPES, PROXIMITY TO STREAMS AND HOUSEHOLD TOPOGRAPHICAL LOCATION ON FLOODING IMPACT IN THE EASTERN CAPE

"Experiencing the need for change is the first step towards mainstreaming sustainability" *Sally Uren*

**Plate 4**. Houses built on mountain slopes dominated by big trees in Green Farm, Port St Johns. (Photo by Mwazvita TB Sachikonye)

## 4.1 Chapter overview

This chapter is concerned with the spatial influence and distribution of flooding impact in the study areas as it relates to patterns of land use, homestead topographical location and state of natural vegetation on flooding impact in the Eastern Cape in response to the third objective of this study (Section 1.11). The results are presented as annotated maps describing identified relationships between ecosystem services, land use patterns and the physical impacts of the floods on the households as well as the responses to the flooding shock. A discussion of the findings as it relates to the overall theoretical framework of this study is presented and subsequent conclusions and recommendations are also presented.

## 4.2 Introduction

Floods are natural phenomena, however, the extent of damage and losses from floods and similar disasters are largely the consequences of anthropogenic activities (Nel et al., 2014; Rahman et al. 2014). The poor and marginalised frequently reside in the most hazardous and unhealthy environments in urban areas especially in informal settlements (Douglas et al., 2008). Many construct their shelter on steep and unstable hillsides, and frequently with poor quality housing material (Khandlhela & May, 2006). The implications of these poor conditions render them vulnerable to flooding shocks which are on the rise due to climate change (Wisner et al., 2004; DST South Africa, 2010; Henderson-Sellers & McGuffie, 2011).

Flooding in urban areas is not exclusively caused by heavy rainfall and extreme climatic events, but is also strongly related to changes in the built-up areas themselves (Douglas et al., 2008). Natural drainage channels of storm water are greatly limited by impervious surfaces on roofs, roads and pavements. Artificial drainage systems developed in urban areas also affect peak stream flow discharges by speeding up and increasing the velocity and volume of storm water (Benjamin, 2008). There therefore exists a clear bio-physical dimension to the vulnerability and exposure of the urban poor to flooding. The response capacity of households is also affected by the natural environment.

River gradient can be used as an indication of potential flash flood risk areas. River gradient is the ratio of drop in elevation of a river per unit horizontal distance, usually expressed as metre drop per kilometre length of river (Pramojanee et al., 2001). An adaptation of this concept has been used in this study in which surface run-off risk was measured using a Digital Elevation Model (DEM). A high gradient indicated a steep slope and rapid flow of water (i.e. more ability to erode); whereas a low gradient indicated slow moving water. It is understood that areas along or at the immediate downstream of a river, and in this study, downstream of a slope with high gradient, are more prone to flash flooding (Cappiella et al., 2005). In general, such flash floods have rapid runoff and debris flow that rises quickly with little or no advance warning to prevent flood damage (Douglas et al., 2008).

A geographic information system (GIS) is a tool that is used to conduct comprehensive spatial analysis of phenomena (Bello et al., 2014). It has been used extensively to generate flood risk maps by analysing the spatial distribution of hydrological data to produce various models, and also to establish the relationship between flooding and topography (Pramojanee et al., 2001). ArcGIS was used to investigate the measure of exposure of Eastern Cape households to flood events according to the observed impact incurred by the households in the October 2012-February 2013 flood event under study. This chapter therefore focused on establishing if and how differences in land cover types and household topographical location exacerbate or diminish physical impacts of flooding in response to the third objective of this study. To do this, it investigated the presence of any apparent differences in land cover types that can be related to the differences in the severity of damage to land or property, and also examined the influence of the topographic position of the homestead and its proximity to water bodies on the physical impact of the flood to housing structures.

## 4.3 Study area and methods

The study was conducted in three towns in the Eastern Cape, namely Grahamstown, Port Alfred and Port St Johns (Chapter two). A total of 236 households were interviewed via a questionnaire, and by means of weighting, three causative factors including proximity of households to drainage channels, slope factor and land use were compared to the physical impact of flooding on housing structure in ArcGIS software to rate the degree of risk to flooding.

### 4.3.1 ArcGIS

In a study conducted in the greater Manchester area investigating the risk of urban areas to surface water flooding, Kazmierczak & Cavan (2011) using ArcGIS analytical tools concluded that the levels of risk of surface water flooding are determined by factors associated with topography and land use. This study therefore used 2009 1:10 000 aerial photographs sourced from the Department of National Geo-Spatial Information (NGI) of South Africa showing patterns of land use and cover along with 1:50 000 topographical maps for the three towns. To identify areas of highest risk to flooding impact, the following conditions were be separately considered from the maps and aerial photographs:

- Households location along a specific slope factor and

- Households located in an area with a small ratio of surface covered by intact natural vegetation to impervious surfaces covered by pavements, roofs, roads or bare gravel and
- Households located within 50-200 metres of a stream channel;

In theory, there are more factors that contribute to the flooding risks such as daily rainfall, soil type and the geomorphology and hydrology of the watershed. These and other factors were excluded from this analysis as the data were either not available, limitations of the software available and technical expertise to adequately analyse the data, and also by virtue of not being relevant in answering the objective under investigation which focuses on patterns of land cover (Pramojanee et al., 2001). Causative factors that included slope factor and relationship to location of household, patterns of land use, proximity to drainage channel and housing type were compared to impact in rating the degree of risk that each factor contributed following Pramojanee et al. (2001), Benjamin (2008) and Kazmierczak & Cavan (2011).

The GPS coordinates per household were identified as push pins in Google Earth were placed onto the aerial photographs so as to accurately place the households using ArcMap as points for analysis. The coordinates were therefore imported into ArcMap and layered with the respective aerial photograph and topographic map, after they had been appropriately geo-referenced and corrected to the Transverse Mercator (27) projection (Bello et al., 2014). The study areas were then clipped into their respective towns and saved as new layers. Polygons to border each settlement according to the household coordinates were then created by drawing a boundary at 10 metres from the households on the outermost margins, and attribute data was added in tables to the polygons.

As there was no prior knowledge of the study area in terms of having a classification scheme being developed for the area as Bello et al. (2014), an unsupervised cluster classification function was used instead of a supervised classification. Raster cells in ArcGIS were used to identify and classify areas covered by roofs, pavements, bare soil, roads and intact or degraded natural vegetation by creating isoclusters in ArcMap for each settlement polygon area on the 3-band aerial photographs with varying light reflective abilities to produce clusters of different colour bands (Everitt et al., 2002). The extent of each of the various land use and vegetation types was calculated according to the number of cells that defined them, with cells having less than 50 % of a specific vegetation type or land use pattern being excluded.

A topographic analysis was then carried out to identify settlements that were located on steep gradients by creating a Digital Elevation Model (DEM) using the contour lines to calculate the slope factor of the settlements in ArcMap. The percent slope was calculated according to Hickery (2000) by the equation:

$$Slope\ (\%) = \frac{Elevation\ difference\ between\ highest\ and\ lowest\ point}{Length\ of\ slope\ (m)} \times 100$$

Following this, a buffer analysis was carried out to identify areas that were most at risk of stream flooding based on field observation with regards to the flooding distance (representing the floodplain) of the identified streams in the study areas. Buffers were set at 100 m as it was observed in the field that identified streams caused a swamp effect to the ground to an approximate extent of 100 m. These areas were also covered by riparian vegetation, and the ground was constantly wet (Vyas et al., 2012).

By comparing these data to the averages of level of impact to housing structures per settlement as well as the modes and averages of housing materials, relationships between topography, land cover patterns, proximity to streams and the physical impacts of the floods on the households were identified and analysed. This was done using a scoring scale for risk to flooding of 1–5, with one representing low and five representing extreme. The influence of slope factor was calculated by adding the classification of the slope steepness given as a percent to the position (Table 4.1). The bottom of the slope was considered the most risky position due to the decreased erosive ability of water and the increase in deposition and accumulation of debris and water down slope (Breetzke et al., 2013). Low gradient slopes are highly vulnerable to flood occurrences compared to high gradient slopes. Rain or excessive water from the river always gathers in an area where the slope gradient is usually low. Areas with high slope gradients do not permit the water to accumulate and result into flooding (Ouma & Tateishi, 2014).

### 4.3.2 Statistical analysis

To reduce the effect of variation among the different land use/vegetation classes among townships and cities due to varying sample sizes, the data were log(x+1) transformed to stabilise the variance. The data was analysed using a Chi-squared analysis to test for differences between land use/vegetation classes within the different towns and further Chi-square tests were done to test significant differences within the town settlements using PAST version 3.03 (Hammer et al., 2001). Multiple regression analyses were done using Statistica (StataCorp, 2011) after the data were square root transformed. The regression was used to analyse the relationships of slope factor, proximity to water bodies and land cover patterns to the physical impact on housing structures.

**Table 4.1**: Scoring matrix for assessing level of risk to households

| Risk level | Score | Slope factor (%) | Proximity to water (m) | Surrounding land cover (10 m radius) |
|---|---|---|---|---|
| Low risk | 1 | 0-5, top, middle, bottom | >130 | Small trees/medium to dense bush |
| Moderate risk | 2 | 0-10, top | 121-130 | Sparse shrubs |
| Medium risk | 3 | 11-30, top;<br>0-10, medium | 101-120 | Pasture/cultivated/grass |
| High risk | 4 | 11-30, middle;<br>0-10, bottom | 51-100 | Mostly bare/exposed topsoil |
| Extreme risk | 5 | 11-30, bottom | 0-50 | Mostly built/paved |

## 4.4 Results

### 4.4.1 Spatial differences between towns and settlements

Up to five main land cover types were identified in the settlements in the three towns (Figures 4.1–4.3). These were small trees and dense bush, shrubs, grasses and pasture, gravel and roads, paved surfaces and roofs. Grahamstown was observed to be 39 % dominated by pasture and short grass. Port Alfred was dominated by shrubs and grass (33 %), and 35 % of Port St Johns was covered by dense bush and short trees, which was the dominant land cover (Table 4.2). No significant (Chi-square = 6.8, $p > 0.05$) differences were observed among the overall land cover patterns in Grahamstown, but significant ($p < 0.05$) differences were observed in Port Alfred (Chi-square = 9.36) and Port St Johns (Chi-square = 10.68). Using Chi-square analysis, significant ($p < 0.05$) differences of land cover patterns were observed between Phaphamani–Sun City in Grahamstown (Chi-square = 9.64, $p = 0.012$), Biso–Cricket Park (Chi-square = 7.11, $p = 0.022$) and Biso–New Rest (Chi-square = 5.99, $p = 0.012$) in Port Alfred, and Gapiri–Sikilikili (Chi-square = 11.37, $p = 0.013$) and Tiger Flats–Sikilikili (Chi-square = 8.25, $p = 0.020$) in Port St Johns.

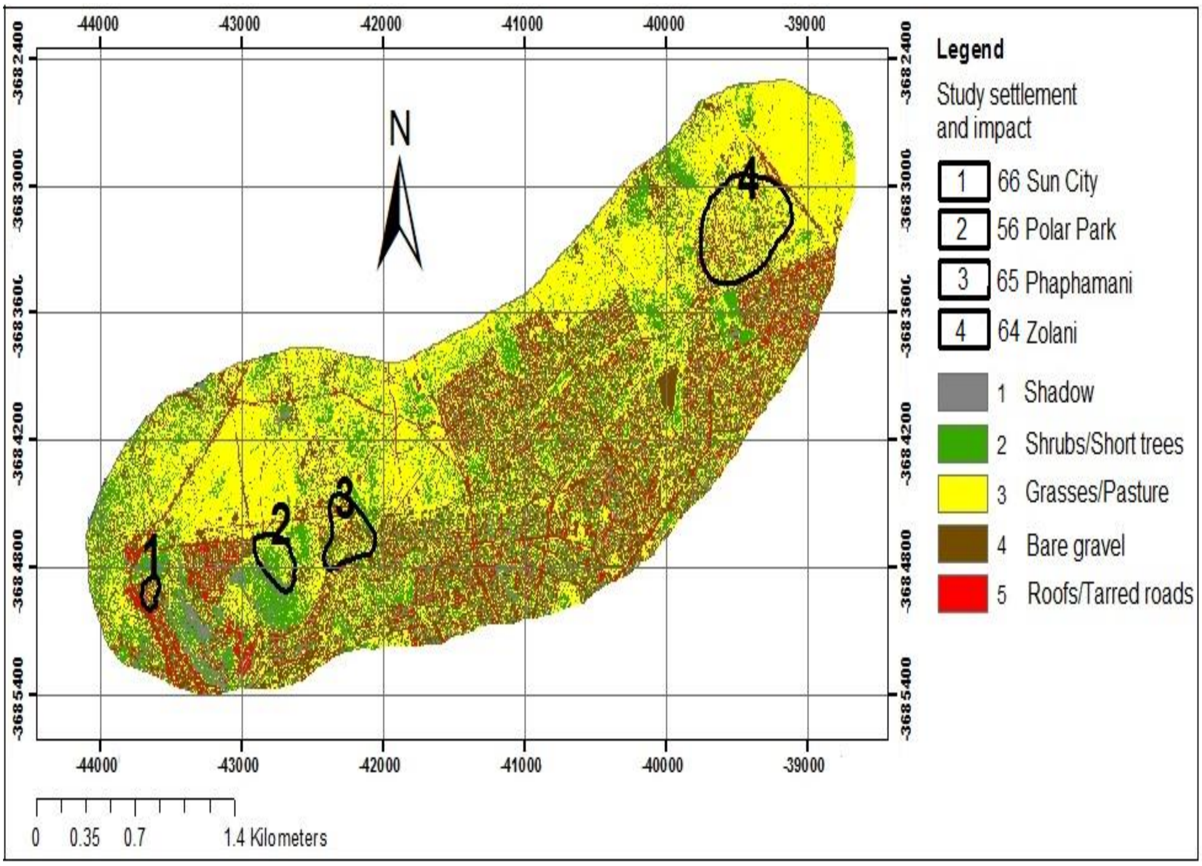


**Figure 4.1**: Main land cover in informal settlements in Grahamstown

In Grahamstown, Polar Park and Phaphamani were located on a 9 % and 20 % slope, respectively. Both settlements were situated in the middle of the slope. Phaphamani experienced mostly extreme impacts on housing structures (level 5) (Table 4.2). In Port Alfred, Biso was observed to have experienced the highest impact. Biso households were located on a 30 % slope, and were situated at the bottom position along the slope in comparison to the other two settlements giving the highest risk score of the three Port Alfred settlements for slope factor. In Port St Johns, Gapiri had 15 households located at the middle of a 15 % slope, and was found to be most affected by slope factor compared to all other settlements in Port St Johns.

**Table 4.2**: Summary of results of impact, housing material, land cover and gradient for informal settlements of Grahamstown, Port Alfred and Port St Johns

| Settlement | Total area of settlement (ha) | Total impact (%) | Modal class of impact | Modal class of roof material of HH's | Modal class of walls of HH's | Dominant land cover | Dominant land cover (%) | Slope gradient (%) | Slope position |
|---|---|---|---|---|---|---|---|---|---|
| **Grahamstown** | **39.3** | **62.6** | **4** | **3** | **3** | **Pasture, short grass** | **39.3** | | |
| Sun City | 1.4 | 55.6 | 4 | 3 | 3 | Bare gravel, roads, roofs | 58.7 | 18 | Mid |
| Polar Park | 5.3 | 63.6 | 4 | 3 | 1 | Small shrubs, tall grass | 55.4 | 9 | Bottom |
| Phaphamani | 8.2 | 65.4 | 5 | 3 | 1 | Pasture, short grass | 57.7 | 20 | Mid |
| Zolani | 24.4 | 65.7 | 4 | 3 | 1 | Bare gravel, roads, roofs | 39.5 | 2 | Top |
| **Port Alfred** | **20.2** | **68.3** | **5** | **3** | **3** | **Shrubs, small trees** | **33.1** | | |
| Biso | 2.5 | 73.3 | 3 | 3 | 3 | Shrubs, small trees | 39.5 | 30 | Bottom |
| Cricket Park | 7.5 | 61.7 | 3 | 3 | 3 | Short grass, pasture | 32.5 | 10 | Mid |
| New Rest | 10.2 | 70.0 | 5 | 3 | 3 | Shrubs, small trees | 33.4 | 4 | Mid-high |
| **Port St Johns** | **33.7** | **55.2** | **4** | **3** | **1** | **Dense bush, small trees** | **35.6** | | |
| Gapiri | 11.4 | 23.5 | 0 | 3 | 4 | Dense bush, small trees | 37.5 | 15 | Middle |
| Green Farm | 8.4 | 62.5 | 4 | 3 | 1 | Shrubs, small trees | 31.6 | 33 | Bottom |
| Tiger Flats | 11.3 | 69.5 | 4 | 3 | 1 | Dense bush, small trees | 36.2 | 21 | Bottom |
| Sikilikili | 2.6 | 65.3 | 4 | 3 | 2 | Dense bush, small trees | 37.1 | 1 | Middle |

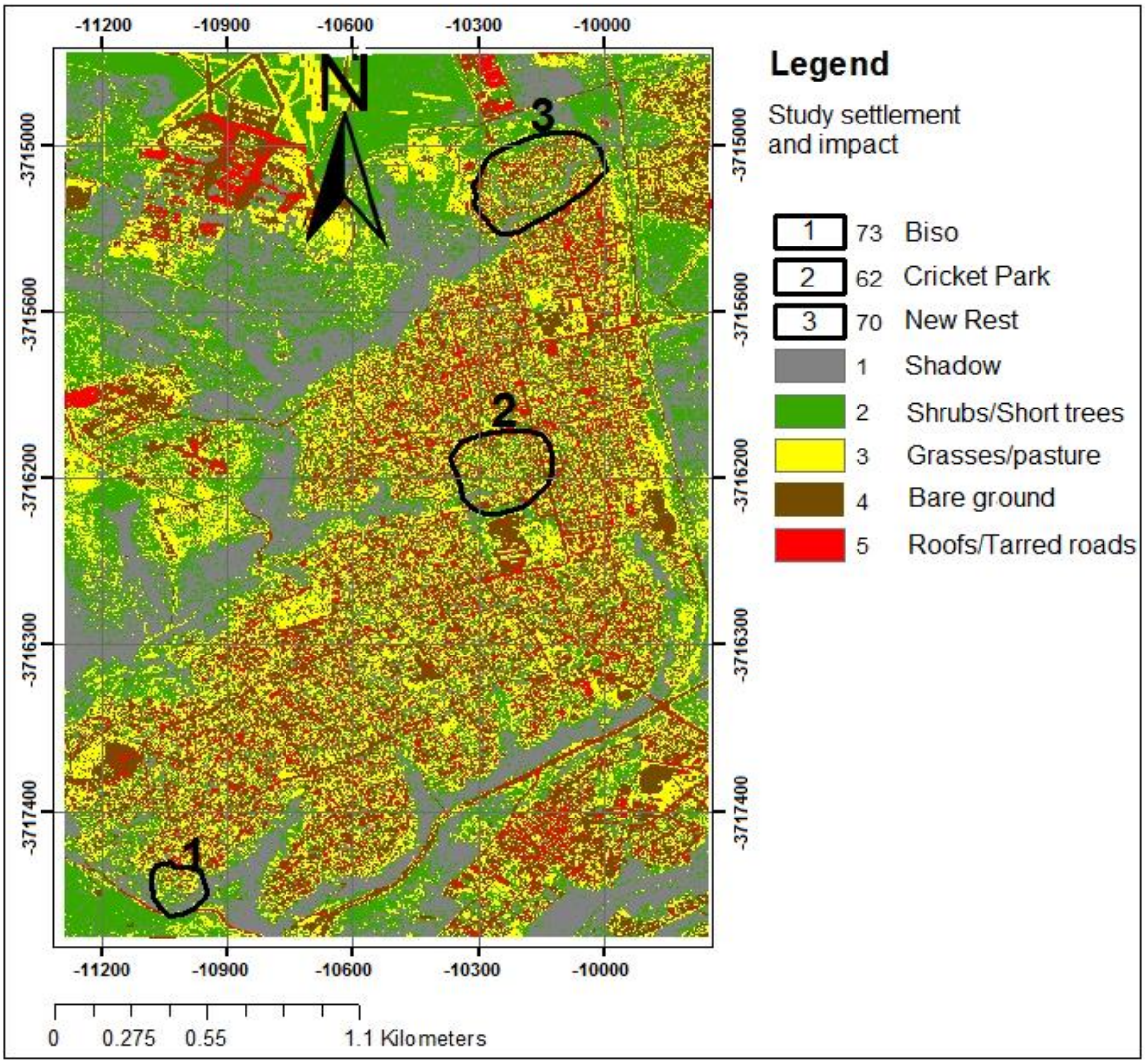


**Figure 4.2**: Main land cover in informal settlements in Port Alfred

In Grahamstown, with the exception of Zolani, all settlements were within a 100 m buffer of a stream. Phaphamani had two streams dissecting households, with six households within 20 m of the non-perennial river whereas Sun City and Polar Park had streams extending only to the 100 m buffer, but not reaching into the household boundaries (Figure 4.4). In Port Alfred, Cricket Park and New Rest had streams dissecting households. Four households in Cricket Park were located slightly downstream from the stream at a distance of between 20 m and 45 m, whilst the rest were located slightly upstream. In New Rest, many of the households were located within 20 m of the streams that dissected the settlement (Figure 4.5). In Port St Johns, Sikilikili was surrounded by two wetlands and was also within a 100 m of the Umzimvubu Estuary (Figure 4.6). Tiger Flats was within a 100 m of a wetland (Figure 4.6). Green Farm households were located immediately downhill from two streams, whereas Gapiri was not located near any streams (Figure 4.7).

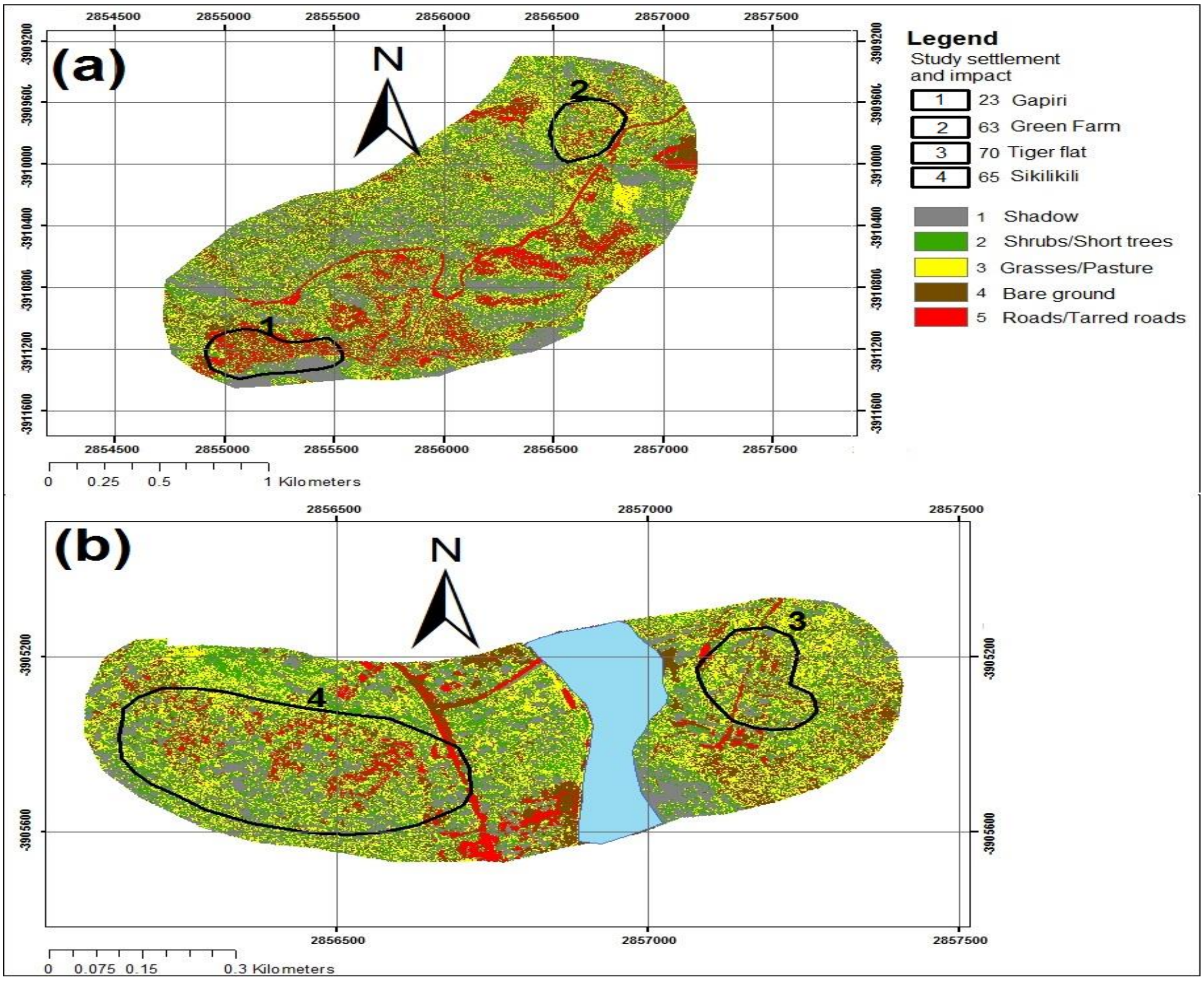


**Figure 4.3**: Main land cover in informal settlements in Port St Johns: (***a***) Gapiri and Green Farm, and (***b***) Tiger Flats and Sikilikili

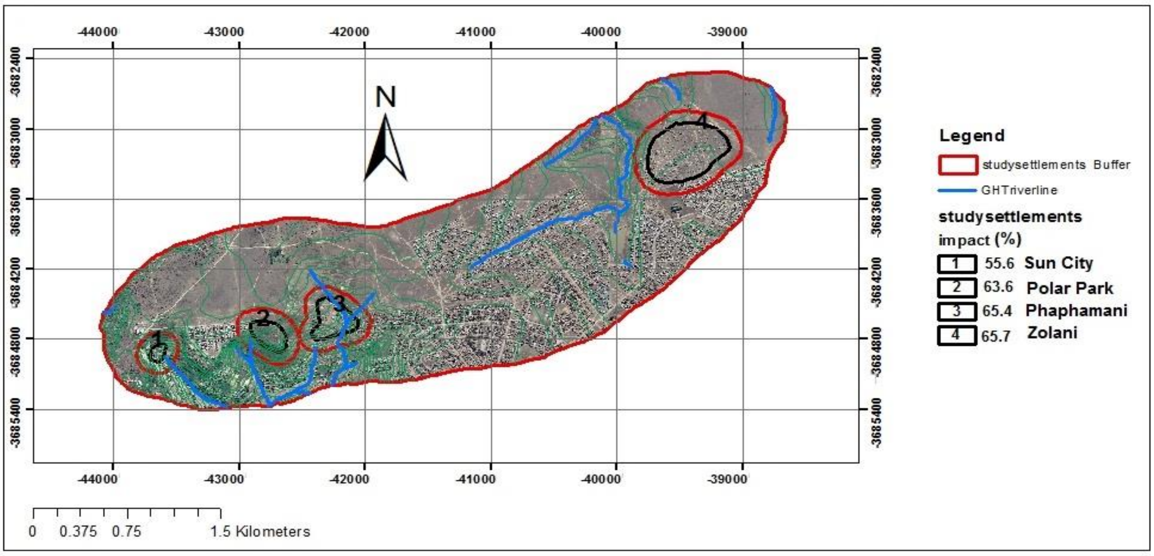


**Figure 4.4**: Proximity to water channel buffer analysis of Sun City, Polar Park, Phaphamani and Zolani, Grahamstown

### 4.4.2 Risk assessment of households

In Grahamstown, Sun City was found to have just over 20 % of households being at an extreme risk to flooding due to their proximity to small streams. Zolani was observed to be most at risk due to its land use patterns (40 % of households at extreme risk) (Figure 4.8). In Port Alfred, Biso had the lowest risk score as far as its proximity to streams was concerned. New Rest, however had the highest risk score both for its proximity to streams, and also for its land cover (30 % and 27 % of households with extreme risk, respectively) (Figure 4.8). Biso, however, had the highest impact of 73 %. Biso had just over 65 % of all its households sitting on high and extreme risk slopes (Figure 4.8). In Port St Johns, Gapiri was least at risk as it was far from any stream channels. Sikilikili had the highest risk score for its proximity to water bodies, with about 50 % of its households located in high and extreme proximities to surrounding wetlands and the main Umzimvubu channel (Figures 4.6 and 4.8). Tiger flats had the highest risk score for land use patterns, with just over 60 % of all its households being surrounded by high and extreme risk land cover to flooding.

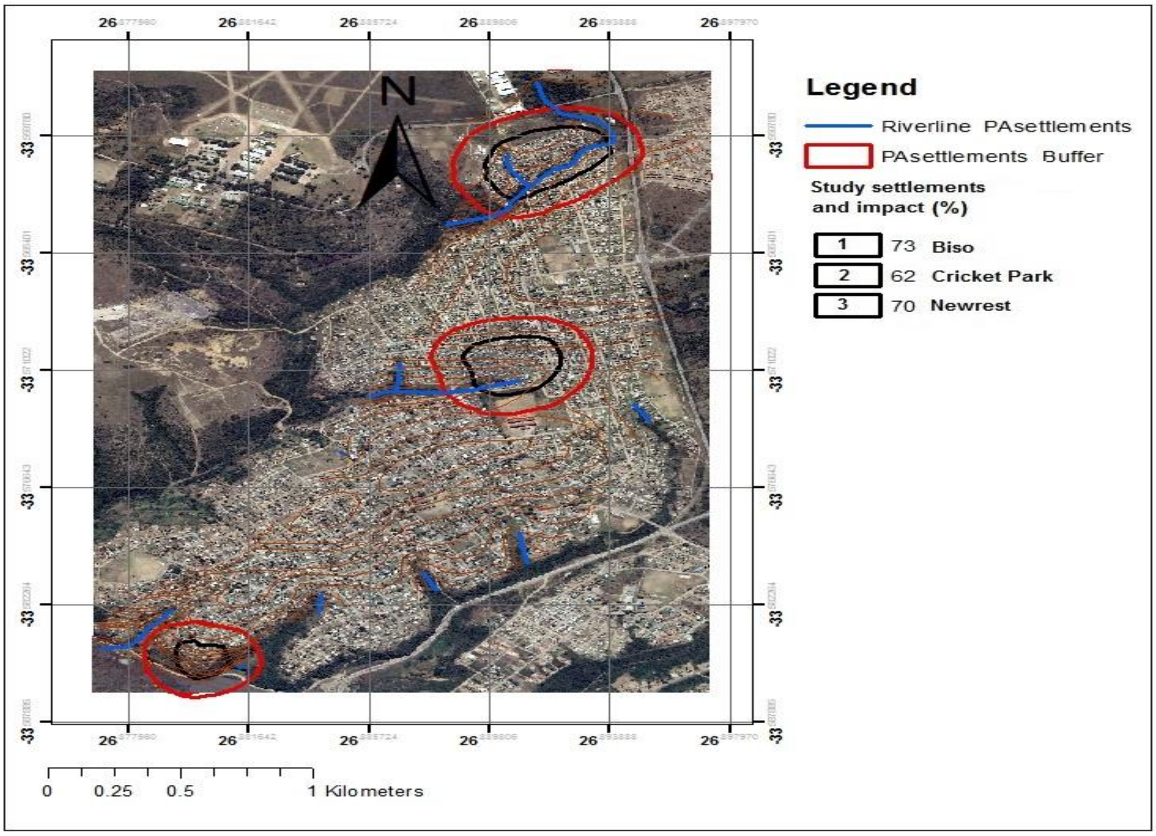


**Figure 4.5**: Proximity to water channel buffer analysis of Biso, Cricket Park and New Rest in Port Alfred

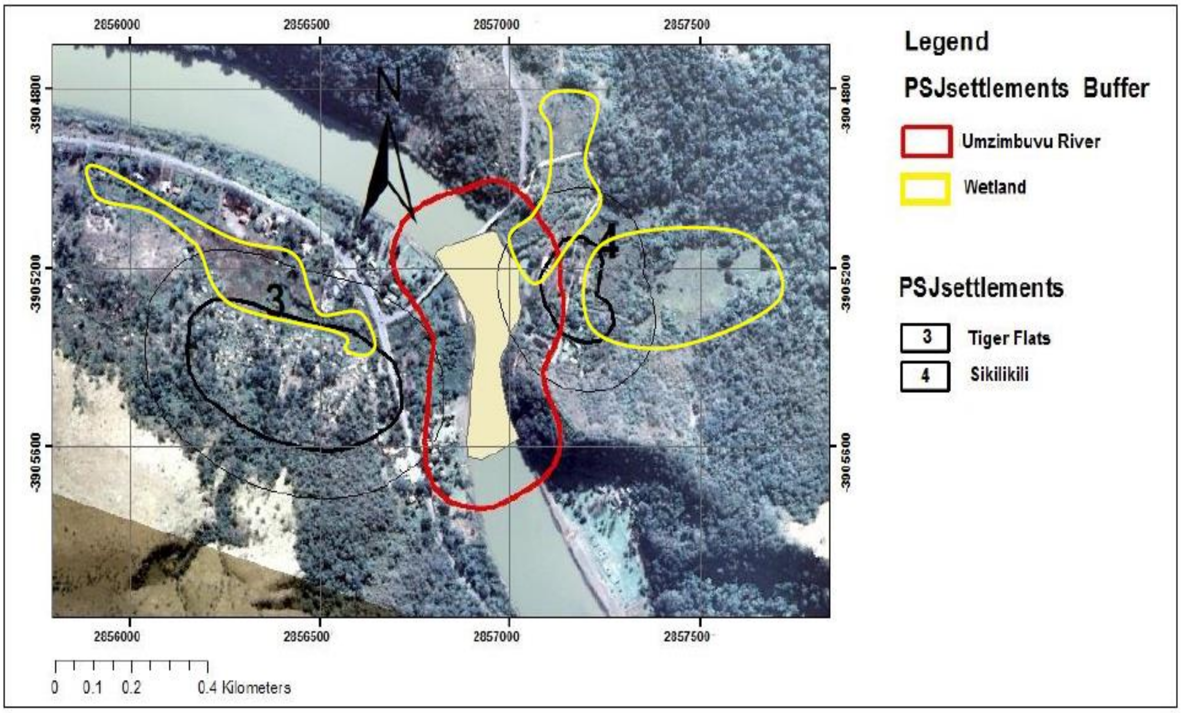


**Figure 4.6**: Proximity to water channel buffer analysis of Tiger Flats and Sikilikili in Port St Johns

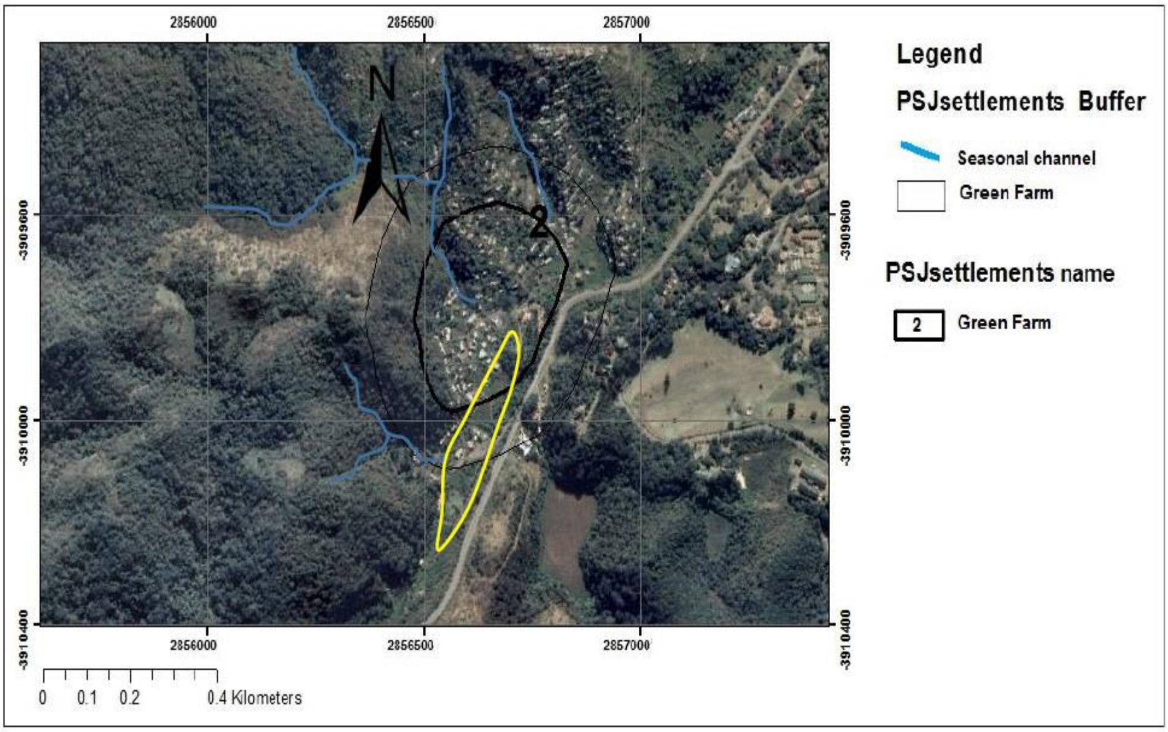


**Figure 4.7**: Proximity to water channel buffer analysis of Green Farm in Port St Johns

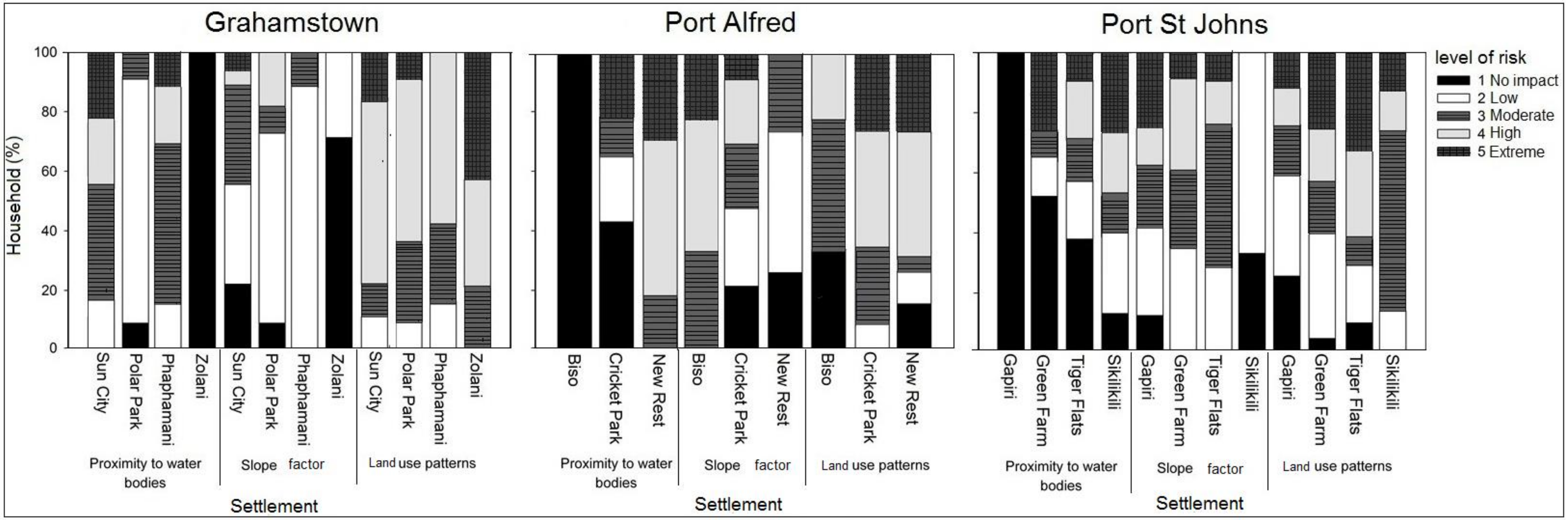


**Figure 4.8**: Household risk levels in all study locations due to proximity to water bodies, slope position and land use patterns

### 4.4.3 Influence of land cover patterns, slope factor and proximity to water bodies on physical impacts on housing structures

Table 4.3 reports the results of a regression analysis of how land cover types, proximity to streams and the household topographical location influenced the impact on housing structures. In Grahamstown overall, it was found that household impact increased with land use cover ($p < 0.05$) and this accounted for 15 % of the variance (Table 4.3). In Phaphamani specifically, it was found that flooding impact increased with increased impervious cover such as roofs and tarred roads, pavements and bare gravel accounting for 62 % variance at 1% significance level. Phaphamani had an impact score of 65 %, which was the second highest impact score in Grahamstown (Table 4.3).

**Table 4.3**: Regression results of influence of identified factors on impact to housing structures for all households in Grahamstown, Port Alfred and Port St Johns

| **Factor** | **Proximity to water bodies** | **Slope factor** | **Land cover patterns** | **Material of house walls** |
|---|---|---|---|---|
| | ***p-value*** | ***p-value*** | ***p-value*** | ***p-value*** |
| **Grahamstown** | **0.100** | **0.772** | **0.003*** | **0.148** |
| *Sun City* | 0.841 | 0.985 | 0.076 | 0.903 |
| *Polar Park* | 0.950 | 0.289 | 0.632 | 0.189 |
| *Phaphamani* | 0.131 | 0.758 | 0.000** | 0.514 |
| *Zolani* | - | 0.437 | 0.210 | 0.644 |
| **Port Alfred** | **0.335** | **0.147** | **0.133** | **0.059** |
| *Biso* | - | 0.759 | 0.878 | 0.516 |
| *Cricket Park* | 0.448 | 0.719 | 0.461 | 0.591 |
| *New Rest* | 0.363 | 0.134 | 0.090 | 0.131 |
| **Port St Johns** | **0.083** | **0.119** | **0.488** | **0.029*** |
| *Gapiri* | 0.216 | 0.007* | 0.035* | 0.449 |
| *Green Farm* | 0.019* | 0.678 | 0.792 | 0.013* |
| *Tiger Flats* | 0.067 | 0.237 | 0.621 | 0.378 |
| *Sikilikili* | 0.625 | 0.067 | 0.036* | 0.644 |

***, * represent 1% and 5% levels of significance respectively.* ***Grahamstown****= Regression Summary for Dependent Variable: physical impact on house (Spreadsheet31)* $R^2=0.15032135$ *F(4,78)=3.4499 (n=83).* Phaphamani= *Regression Summary for Dependent Variable: physical impact on house (Spreadsheet21)* $R^2= 0.61768570$ *F(4,21)=8.4822( n=26).* ***Port Alfred****= Regression Summary for Dependent Variable: physical impact on house (Spreadsheet71)* $R^2=0.12581434$ *F(4,65)=2.3387 (n=70).* ***Port St Johns****= Regression Summary for Dependent Variable: physical impact on house (Spreadsheet66)* $R^2=0.11492950$ *F(4,78)=2.5321(n=83)* Sikilikili=*Regression Summary for Dependent Variable: physical impact on house (Spreadsheet62)* $R^2=0.63488569$ *F(4,10)=4.3472 (n=15)* Green farm= *Regression Summary for Dependent Variable: physical impact on house (Spreadsheet53)* $R^2=0.45056137$ *F(4,18)=3.6902 (n=23)* Gapiri= *Regression Summary for Dependent Variable: physical impact on house (Spreadsheet49)* $R^2=0.43618978$ *F(3,20)=5.1576 (n=24)*

Overall, in Port St Johns, the use of more robust housing material of the walls (brick) significantly ($p < 0.05$) reduced the impact of flooding for 11 % of the variance (Table 4.3). In Gapiri, higher risk slopes and land use patterns resulted in a significantly ($p < 0.05$) higher impact on households, accounting for 44 % of the variance. It was also observed in Green Farm that with an increased proximity to water bodies, and risky housing material, there was a significantly ($p < 0.05$) higher impact from the flood for 45 % of the variance. The regression analysis also revealed that the impact on household in Sikilikili was significantly ($p < 0.05$) increased by an increase in risky land cover patterns for 63 % of the households.

## 4.5 Discussion

Similar to findings in Kampala, the construction of unregulated shelters by the urban poor in the form of slums, greatly reduced infiltration of rainfall, increasing runoff up to six times greater than which would occur over natural undisturbed vegetation (Douglas et al., 2008). This can be attributed to land cover change, as also observed in the findings of Kazmierczak & Cavan (2011), who found that in Manchester, over 14.2 % of the Greater Manchester area is susceptible to surface water flooding, and 2.2 % is highly susceptible, concluding that the varied distribution suggests that the levels of risk of surface water flooding are determined by factors associated with topography and land use. Liu et al. (2014) found that in a community in Haidian district of Beijing, run-off from the impervious area, which occupied 70 % of the total surface accounted for 58.6 % to 66.8 % of the total precipitation. Run-off from the pervious area (30 % of the total surface) were considerably lesser and accounted for 3.3–12.7 % of the precipitation, depending on the storm recurrence periods. In settlements of high household densities, i.e. where houses were close together, the impact on shelters was found to be greater. Population increases with no significant improvements on the drainage systems facilitates an increase in flooding incidence and also intensity (Douglas et al., 2008).

Quite like the households in the Maili Saba slum in Nairobi Kenya, the impact of flooding is exacerbated by the inadequate building materials used by the poor (Douglas et al., 2008). This is discussed in greater detail in Chapter three. This finding was consistent with Ouma & Tateishi (2014), whose results of the vulnerability study to flooding of the Eldoret Municipality in Kenya, revealed that four-fifths of the study area was prone to “very low” to “moderate” level of flood hazards. Most of these areas tended to be on the higher ground and further away from the high drainage density areas. Significantly, their results depicted the fact that Eldoret Town’s central business district (CBD) was prone to “moderate” flooding vulnerability. This was because despite the CBD having drainage networks, most of them were clogged and that the urban paved surfaces hindered water infiltration, these areas were prone to flooding events during heavy rainfall occurrences. Indeed, the average flood impact of Gapiri households was 23.5 %, which was the lowest of the Port St Johns households, and in the entire study sample.

Ouma & Tateishi (2014) found that almost a fifth of the total Eldoret Municipality in Kenya was prone to “high” and or “very high” flood hazards. These areas were those that were close to the rivers and generally laying at low elevations within the settled/paved regions. Green Farm is located in the drainage basin of two non-perennial streams, and also sits at the bottom of a 33 % slope, which is the steepest slope of all the settlements (Figure 4.7, Table 4.2). Although only five of the households in the settlement were constructed with mud walls and 16 with brick walls, the households were largely affected by the swamp effect that results from the accumulation of debris and water in the basin. Furthermore, most of the households were not constructed with foundations that take into account the swamp effect. Wilby & Keenan (2012) found that between 2000 and 2011, the development in flood risk areas of buildings constructed in areas of coastal, river and surface water flooding that were not taking into account flood defences were increasing. This was subsequently also increasing their vulnerability to flooding, and this was observed to also be true for Green Farm households. Furthermore, households that are located close to a drainage channel are affected by the accumulation of sediment and rubbish, which in turn poses a great threat of flooding due to the reduction of the capacity of the channel to contain water (Foley et al., 2005), mostly observed at the bottom of the slope. In Green Farm, the accumulation of mostly sediment at the bottom of slopes was found to compromise drainage and facilitated the accumulation of water in basins. Green Farm was located on top of a swamp/ wetland area, which was found to have the highest runoff coefficient of 0.8 in a study conducted in Rio de Janerio by Barbedo et al. (2014). It was also found in Port Harcourt in the Niger Delta that the blockage of channels by debris and the obstruction of flood paths by new construction were seen to be the most contributing factors to flooding experienced in the area. Houses located next to drainage channels were also found in the low lying areas or at the bottom of slopes (Benjamin, 2008; Douglas et al., 2008).

Adelekan (2010) observed an increase in the intensity of urban flooding related to the decrease in natural vegetation cover, including mangrove and swamp thicket which was reduced from 30 % to 19 % in the poor urban coastal communities in Lagos, Nigeria, similar to results from Sikilikili (Figure 4.6). Although the proximity of Sikilikili was not found to have significantly ($p < 0.05$) influenced the impact on housing structures, Sikilikili is located in a riparian buffer zone for a large river, and also on a wetland area. These areas play an important regulatory ecosystem function, and are sensitive to alterations in land cover patterns as seen in Ming et al. (2007) who found that the unit area for flood mitigation benefit was 7.15×104 $m^{-3}hm^{-2}yr^{-1}$, the area of the east region was 4.40× 104 $m^{-3}hm^{-2}yr^{-1}$, the area of the middle was 8.42×104 $m^{-3}hm^{-2}yr^{-1}$, and the area of the West was 7.86×104 $m^{-3}hm^{-2}yr^{-1}$ in the Momoge National Nature Reserve in China, proving the spatial extent of flood mitigation benefits. In Sikilikili, approximately 60 % of riparian zone vegetation was converted into residential houses, pasture and agricultural land. This is similar to the findings of Georgia (2009) who found that the 56 % of the Alcovy River's riparian buffer zone had been converted to residential land use patterns. In contrast, Apan et al. (2002) reported that in the Lockyer Valley catchment in Australia found only up to 36 % of the buffer zone forests had been replaced by human activities. Vyas et al. (2012) found in their investigation of the overall status of the riparian buffer zone and floodplain of the River Narmada, India, that the zone was dominated by agricultural practices and human habitation by 74 %, and found this to largely affect the river ecosystem functions.

## 4.6 Conclusions and recommendations

Land cover patterns were found to have significantly influenced the physical impact of flooding on housing structures of Grahamstown. In Phaphamani, they accounted for 62 % of the variance, in Gapiri for 44 % (including slope factor) and in Sikilikili, for 64 % of the variance. In Green farm, 45 % of the variance was accounted by its proximity it water bodies and the material of walls. It can therefore concluded that the impact on housing structures in informal settlements of Grahamstown and Port St Johns during the October 2012 floods were significantly influenced by their proximity to water bodies and slope factor; but were largely influenced by patterns of land cover. No single factor was observed to have influenced the physical flooding impact significantly in Port Alfred, suggesting that the combination of factors resulted in the flood damage in Port Alfred. Kazmierczak et al. (2010) recommend the provision and enhancement of green infrastructure as part of adaptation responses, having found in their study in Greater Manchester that the lack of green spaces coincides with areas that are inhabited by communities most vulnerable to heat waves and urban flooding. They concluded that an absence of regulating services of green infrastructure means that the high temperature and flooding risks to people are further increased. Generally, settlements in Port St Johns were found to have experienced less of the physical damage of the flood. The housing density was much less, and this could have resulted in the flood path not having been obstructed. The presence of vegetation can also be plausible explanation to the reduction in flood impact as suggested by Vich et al. (2014) and Daigneault & Brown (2014) by reducing impermeable surfaces thus reducing surface run-off.

# CHAPTER 5. CONCLUSIONS AND FINAL RECOMMENDATIONS

"…disasters in Africa pose a major obstacle to the African continent's efforts to achieve sustainable development." *United Nations*

**Plate 5.** Informal settlement mud and sticks house built on hill slopes dominated by grasses in Port St Johns. (Photo by Mwazvita TB Sachikonye)

## 5.1 Chapter overview and introduction

Ouma & Tateishi (2014) infer that the conversion of natural land cover to agricultural land, natural vegetation and wetlands to built-up environments and construction on natural drainages as well as increase in the population of those living in flood vulnerable areas (such as flood plains and river beds) have only served to increase the likelihood and intensity of urban flooding. There is a direct relationship between urbanization and hydrological characteristics; decreased infiltration, increased in runoff and increase in frequency and flood height (Kazmierczak & Cavan, 2011). The socio- economic context and vulnerabilities that the urban poor live in only exacerbate the impact of flooding (Adger, 2006; Benjamin, 2008; Douglas et al., 2008). As discussed in Chapter three of this study, often, the poor and marginalised turn to natural resources in an attempt to cope with and adapt to shocks, such as flooding (McSweeney, 2004; Shackleton et al., 2008; Paumgarten & Shackleton, 2011; Wunder et al., 2014). The natural environment itself can also serve to mitigate some of the impacts of flooding to the poor, especially in the absence of hard infrastructure and mainstream inclusion in disaster management in general as seen in Chapter four (Wisner et al., 2004; Kazmierczak et al., 2010; Daigneault & Brown, 2014; Liu et al., 2014).

The aim of the study was to improve understanding of how natural resources contribute to the resilience of vulnerable populations in the Eastern Cape to natural shocks such as floods. In this study, households of highest exposure and vulnerability to flooding were first identified. This was done by separately considering from the maps and aerial photographs:

- Household location along a specific gradient of a slope,
- Household located in an area with a small ratio of surface covered by intact natural vegetation to impervious surfaces covered by pavements, roofs, roads, bare gravel or degraded natural vegetation, and
- Households located within 50–200 m of a stream channel.

Each household also had a unique identity field assigned to it, and attribute data of housing type and level of flood impact were added to each point representing a single household. This identified hotspots of highest flooding impact. A final condition was that all areas of high livelihood risk be categorised. Data collected in the questionnaires on the vulnerability context, damage and loss and the contribution of natural resources and subsequently synthesised in Statistica (StataCorp, 2011), SigmaPlot (SigmaPlot, 2006) and PC-ORD

(McCune & Mefford, 2006) were analysed and quantified. The data were household dependencies and income, damage and loss in ZAR, material of housing physical impact on housing structures as well as the amount of natural resources harvested and used in coping and adaptation.

## 5.2 Vulnerability and exposure to flooding

Vulnerability was defined for the purposes of this study as:

$$V=F\{E(A);S(A)\}$$

where, V is vulnerability, as defined above; E is exposure (exogenous variable) which is the likelihood of the human system being affected by a natural event, or climate stimulus; S is sensitivity (endogenous) which is the degree to which a system would be affected by the exposure; and A denotes adaptive capacity which is the ability of human systems to adjust to actual or expected changes in climatic stimuli (Hogarth et al., 2014). In an attempt to gain an understanding of the vulnerability context of households to flooding, a PCA was done to reveal the principal components of socio- economic factors that contributed to vulnerability, and a multiple regression also carried out to understand how bio-pyhsical factors also inlfuenced vulnerability and exposure to flooding. It was found that for the households in the Eastern Cape, vulnerablity to flooding was exacerbated by the following socio-economic factors; having a female household head, a single household head, low education levels in the household, low income diversity, an unemployed household head, low total income (rand), low years of education of head, high number of dependents, low levels of kinship, poor material of house roof and walls, and lastly, vulnerability was higher with increasing number of years in the house. Ownership of the house and the level of access to natural resources were not found to significantly affect levles of vulnerability to flooding (Section 3.4.1; Section 3.4.5). These findings were noted to have been consistent with the extensive studies conducted by Shackleton et al. (2008) (although not in the context of poverty and livelihood security) also in the Eastern Cape, and also provide evidence to support the claims of Green (2008) and Wisner et al. (2004).

## 5.3 Patterns of land cover and household topographical location effect on physical impacts of flooding

Diffrences differences were observed amongst the overall land cover patterns of the towns in the study area in Grahamstown, but significant differences were observed in Port Alfred and Port St Johns. Using pairwise comparison based on Mann-Whitney analysis, significant differences of land cover patterns were observed between Phaphamani – Sun City in Grahamstown, Biso – Cricket Park and Biso – New Rest in Port Alfred, and Gapiri – Sikilikili and Tiger Flats – Sikilikili in Port St Johns (Section 4.4.1). The most severe impact to housing structures was seen in Biso in Port Alfred of 73%, which was 39 % dominated by small trees and sparse shrubs, and was also located at the bottom of a 30 % slope. Most of the houses were also built with walls made of zinc sheets. The least severe impact to housing structures was observed in Gapiri, Port St Johns of 24 %. Gapiri was observed to have dominated by 38 % dense bush and small trees, and also to have had most housing structures built with brick walls.  Gapiri was located in the middle of a 15 % slope (Section 4.4.2). The influence of bio-physical factors was found to differ spatially. Land cover patterns were found to significantly increase flooding vulnerability for Phaphamani, Gapiri and Sikilikili. Slope factor significantly increased flooding vulnerability in Gapiri, whilst proximity to water bodies siginificantly increased flooding vulnerability in Green Farm as did the material of the house walls (Section 4.4.3). The spatial context of vulnerability was thus found to differ, and, consistent with the findings of Douglas et al. (2008) who studied flooding pattern in Africa, and Benjamin (2008) whose study was conducted in South Africa, and the findings of Onishi et al. (2014) whose study was in the urban areas of Dhaka, land use patterns were a significant factor in increasing and intensifying urban flooding incidence.

## 5.4 Relative contribution of natural resources to recovery strategies

There was evidence of households in the Eastern Cape using natural resources to cope and adapt to flood shocks. Natural resources were observed to have contributed mostly to reconstruction, and much less to economic recovery, as many households did not depend on them directly for subsistence or income. In Grahamstown, a total of 47 households used natural resources for reconstruction, meanwhile only five households turned to natural resources for economic or subsistence recovery. In Port Alfred, 36 households turned to natural resources for reconstruction material, whereas no households turned to natural resources for economic or subsistence recovery. In Port St Johns, 54 households used natural resources for reconstruction, whilst nine households used them for economic and subsistence recovery. Overall, Port St Johns households had the highest contribution from natural resources, with a household mean contribution of ZAR817±683 amounting to a mean relative contribution to loss of 70 % per household. Port Alfred had the least relative contribution to loss from natural resources of 46 % per household. Grahamstown had a mean contribution of ZAR723±696 per household, amounting to a relative mean contribution to loss of 55 % per household (Section 3.4.4).

Several factors were observed to increase or decrease the ways in which natural resources were used for coping and adaptation. The multiple regressions revealed that in Grahamstown, higher household income resulted in decreasing use of natural resources in recovery, whereas an increase in kinship resulted in an increasing use of natural resources in recovery, accounting for 49 % of the variance. Similar to Grahamstown, in Port Alfred, kinship was also found to increase the use of natural resources, as well as the cost of replacing or fixing housing structures. However, it was also found that the greater the physical impact on the housing structure, the less people turned to natural resources. In Port St Johns, an increase in kinship and in the number of years of education of the household resulted in a decrease in the use of natural resources in recovery, and this differed from Grahamstown and Port Alfred possibly for the reason of the differences in the extent to which the communities were affected by the flood as discussed in Section 3.5. Also, unlike Port Alfred however, an increase in physical impact to the housing structure and replacement cost resulted in an increasing use of natural resources. In all cases, however, barriers to use of natural resources did to not have a significant influence on the use of natural resources. Although the issue of access to natural resources was found not to significantly influence uptake of natural resources, contrary to Green (2008), all other findings echoed those of Shackleton & Shackleton (2004), Mcsweeny (2005) and Wunder et al. (2014).

## 5.5 Household strategies used to recover from flood shock

Households in this study were predominantly affected by flooding by losing or having experienced damage to housing structures, and much less economically. Grahamstown households' average household income and subsistence loss for the four settlements was ZAR57±178 per household.The average household income and subsistence loss for the three settlements in Port Alfred came to ZAR153±371 per household and in the four settlements on Port St Johns, it came to ZAR187±350 per household. These amounts also factor in damage and loss to household property. The average cost of replacement for a housing structure was highest in Port Alfred, with a mean of ZAR 1 156±535 per household and lowest in Port St Johns with a mean of ZAR758±476 per household (Section 3.4.2). Relative to the average annual incomes, none of the settlements lost over 10 % of their annual income in flood damages and losses. Port Alfred settlements collectively suffered the least loss. On the other hand, Tiger Flats and Sikilikili in Port St Johns experienced the highest loss relative to annual income.

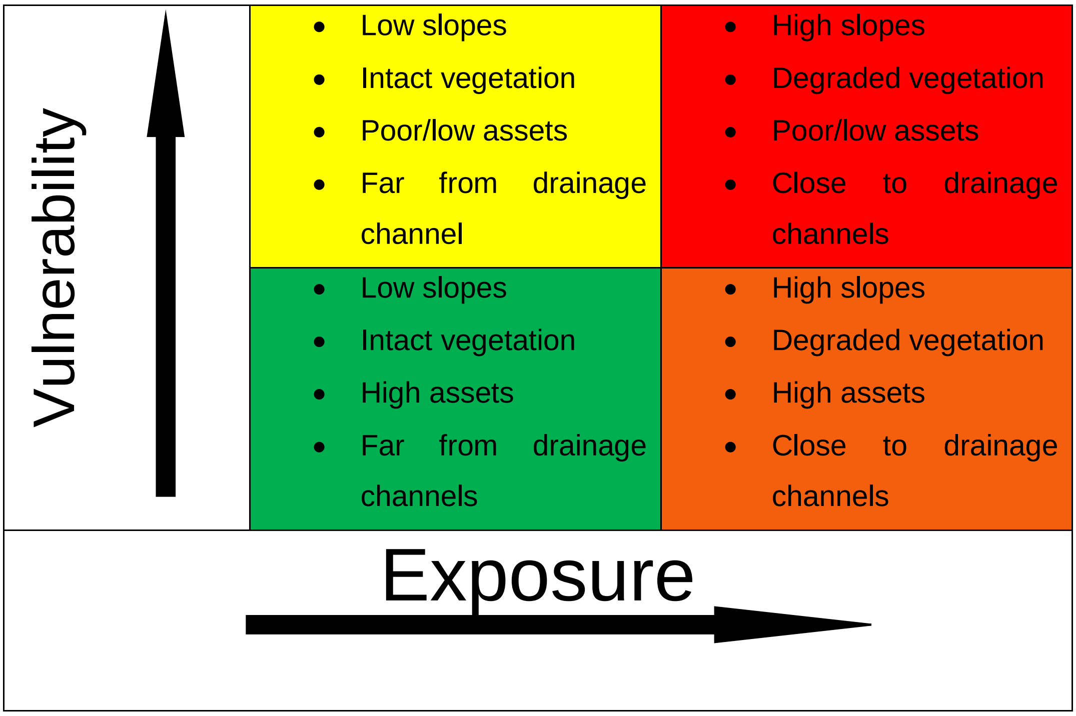
Four main strategies were evident for coping and adaptation to the flooding shocks in all towns, but to varying extents. These were bailing water out of houses with buckets, propping valuable assets on higher levels, receiving emergency assistance and using natural resources, much like the strategies identified by Douglas et al. (2008). There was no evidence that suggested any collective efforts initiated at the community level to cope with the flooding by the residents themselves. Rather, 46 % of all households, mostly in Port Alfred, relied on emergency relief which came in various forms from food to blankets, and even to building supplies in the form of DCP plastic or corrugated zinc sheets from local disaster management offices. Up to 57 % of households in Port St Johns and Port Alfred reported having been temporarily sheltered elsewhere away from their flooded homes, and in other cases, in Port Alfred specifically, this resulted in permanent relocation to new council houses. In all cases, no financial aid was reported to have been received. Although kinship was also found to be a coping strategy, it was mostly used as labour to assist with repairing the housing structures either with natural resources collected or with the DCP plastic or corrugated zinc sheets provided as emergency aid, especially in female-headed households, consistent with the findings of Paumgarten & Shackleton (2011). Natural resources were used extensively for rebuilding and/or reinforcing housing structures, including the use of sand bags to prevent the ingress of water, similar to what Davenport et al. (2012) also found in their study in the Eastern Cape of the use of commonage. Natural resources were very rarely used to substitute income or subsistence in all towns, and this may have been a consequence of the reliance on social grants as suggested by Shackleton et al. (2008) and Davenport et al. (2012) (Section 3.5.2).

## 5.6 Conclusions and recommendations

Using the Sustainable Livelihood Framework, the vulnerability context was defined by the flooding shock. This vulnerability context was found to interact and affect the asset pentagon, which in turn defined the livelihood outcomes, which in this study, was the various ways in which households were found to have coped and adapted to the vulnerabulity context, i.e. was the October 2012 floods. The specific focus of this study was with the contribution of natural resources, which directly affect the physical and natural capital of the asset pentagon, and also the financial, social and human capital, though less directly.

Using the vulnerability and exposure indicators shown in Figure 5.1, it was observed that Gapiri in Port St Johns had the most households with the least vulnerability and exposure to flooding of all the settlements sampled. It was also concluded that Sikilikili and Tiger Flats in Port St Johns had the most vulnerable and the most exposed households to flooding. Gapiri was found in this study to have the second highest mean household income per annum (ZAR28 500± 22 714). Gapiri also experienced the least loss of livelihood from the flood overall (3.3 %). Although Sikilikili was not found to have the lowest mean annual income per annum per household, it was found to have experienced the second highest impact to livelihood of 9.6 %, whilst Tiger Flats was found to have the highest of 9.8 %.

Much evidence on the ways in which resources are used and waste is generated, and on the changes in land cover patterns shows that urban areas are most accountable to unsustainable ecological practices. The dependence of the urban poor on provisioning ecosystem services as evidenced by the finding of this study, may mean a reduced adaptive capacity of urban landscapes related to natural shocks such as floods (Wisner et al., 2008). Given that unique socio-economic and bio-physical factors affected vulnerability and livelihood strategies of households in the Eastern Cape to flooding, it is important that adaptation planning be developed at a municipality level. The challenge thus presented going forward is how to properly integrate social and environmental criteria and marry these to the economic interests which govern the decision-making process affecting mitigation and adaptation to climate change (Chelleri & Olazabal, 2012). According to Dodman & Satterthwaite (2008) and Daigneault & Brown (2014), this planning should take into consideration identifying the risk of flooding as dictated by the current climate trends and future projections, and assessing the climate vulnerability of the urban area at a sectorial level, as done in this study.



| | |
|---|---|
| • Low slopes<br>• Intact vegetation<br>• Poor/low assets<br>• Far from drainage channel | • High slopes<br>• Degraded vegetation<br>• Poor/low assets<br>• Close to drainage channels |
| • Low slopes<br>• Intact vegetation<br>• High assets<br>• Far from drainage channels | • High slopes<br>• Degraded vegetation<br>• High assets<br>• Close to drainage channels |

**Figure 5.1**: Increasing physical exposure and livelihood vulnerability

To promote resilience of the urban poor to shocks, the ways in which decisions are made need to recognise self-sufficiency of the urban poor as observed in the findings of this research. Focus must be shifted towards social equity, education and adaptive capacity (Chelleri & Olazabal, 2012). Current and future development plans, such as low cost housing developments that affect informal settlements in South Africa need to be put under the light of current climate variability and expected climate change. This should ultimately result in the prioritisation of adaptation options using consultative tools, including participatory assessment, social accounting matrices and also cost benefit analyses such as those conducted in Fiji by Daigneault & Brown (2014). A municipal adaptation plan needs to be implemented, monitored and regularly reviewed.

Land cover patterns, slope factor and proximity to streams are important factors to consider in analysing vulnerability of a location to flooding (Adelekan , 2010). The main findings of this research revealed that land cover patterns most influenced exposure to the impact of floods. Land cover patterns were observed to significantly influence exposure in Phaphamani, Sikilikili and Gapiri, whose impact scores were 65.4 %, 65.3 % and 23.5 % respectively. Land cover patterns of less than 37.5 % cover of dense bushes and trees were observed to influence exposure for households located on or below 15 % slope factors and steeper. The material of housing walls was found to significantly influence exposure in Green Farm. The significance of this factor however was found to increase exposure when households were built on top of a wetland and were located at the bottom of a 33 % slope. The implication of these findings would be that local municipalities should actively seek to increase dense bushes and small trees to at least 38 % in settlements that are at the bottom and middle of 15 % slopes and steeper. They should also prioritise building projects and relocation of households located on wetlands and in drainage basins of streams.

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# APPENDIX

## Household Flood Survey

### 1. Household details

#### 1.1 Demographic details

#### 1.1.1 Location of household

| | |
|---|---|
| **Household Number** | |
| **Settlement Name** | |
| **Household GPS Coordinates** | |

#### 1.1.2 Socio-political structure of household

| | |
|---|---|
| 1**. Who is the head of this household?**<br>Resident married male [ ] Married male working away [ ] Widow/widower [ ]<br>Divorced [ ] Single/never married [ ] Other, specify? | |
| 2. **If the head of the household is away, who makes most of the domestic decisions?**<br>Wife [ ] Son [ ] Other [ ] | |
| 3. **For how long have you lived in this house?** | *Years* |

#### 1.2 House structural data

| | |
|---|---|
| **1. Do you have title deeds to this house? 1)** | *Y/N* |
| **2. What is the type of material of (most of) the walls? 2)** | |
| **3. What is the type of material of (most of) the roof ? 3)** | |
| **4. How many $m^2$ approx. is the house?** | *$m^2$* |

*2)* ***Key****: 1=mud/soil; 2=wooden (boards, trunks); 3= zinc (or other metal) sheets; 4=bricks or concrete; 5=reeds/straw/grass/fibres; 6=other, specify:*

*3)* ***Key****: 1=thatch; 2=wooden (boards); 3=iron or other metal sheets; 4=tiles; 5=other, specify:*

### 2. Safety net and daily net assessment

#### 2.1 Animals

1. Does your household own any livestock? ***Y [ ] N [ ]*** If **Y**,

| **Animal** | **Number** | **Animal Shelter** | **Store bought Food Source for Animal** | **Relative Contribution** | **Non Store bought Food Source for Animal** | **Relative Contribution** |
|---|---|---|---|---|---|---|
| Cattle | | | | | | |
| Sheep | | | | | | |
| Goats | | | | | | |
| Donkeys | | | | | | |
| Chicken | | | | | | |
| Rabbits | | | | | | |
| Other | | | | | | |

***Key for relative contributions**: 1= less than 20%; 2= up to 50%; 3=more than 50%*

### 3. Land and patterns of use

1. Do you practice any form of activity (agricultural, grazing or otherwise) on this land?
   ***Y [ ] N [ ]***
   If **Y**, please fill in the table below the type of activity, the size of the land, the predominant land cover and the intensity of cover.

| Activity | Approx. Area | Predominant Land Cover | Intensity of Cover |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

***Key for land cover intensity**: 1= less than 10% of total area under vegetation; 2= between 10% and 30% of total area under vegetation; 3= between 30% and 50% of total area under vegetation; 4= between 50% and 70% of total area under vegetation; 5= more than 70% of total area under vegetation*

#### 3.1 Location of land

***Will be determined on the topographic maps.***

### 4. Flood impact

#### 4.1 Structural damage to house

1. Was your house damaged by the flood in any way? **Y[ ] N[ ]**
   If **Y**, please fill in the details of the damage in the table below.

| Part of House Damaged | Number Damaged | Extent of Damage |
|---|---|---|
| Foundation | | |
| Floor | | |
| Wall | | |
| Ceiling | | |
| Roof | | |
| Entire House | | |
| Other, specify: | | |

***Key for extent of damage****: 1=little damage, easy to repair at home; 2=moderately damaged, needs semi-skilled expertise to repair; 3=above moderate damage, needs repair and part replacement; 4= very damaged, repairable, but has some irreversible damage; 5= completely destroyed, need to be completely replaced; other (specify)*

### 4.2 Damage to Income Stream

### 4.2.1 Effect on Animals

1. Where your animal affected by the flooding in terms of loss of life, shelter and food? ***Y[ ] N[ ]***
   If **Y**, please fill in the details of damage in the table below.

| **Type of Animal** | **Injured (indicate number)** | **Damage to Shelter** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

***Key for Shelter****: 1=little damage, easy to repair at home; 2=moderately damaged, needs semi-skilled expertise to repair; 3=above moderate damage, needs repair and part replacement; 4= very damaged, repairable, but has some irreversible damage; 5= completely destroyed, need to be completely replaced; other (specify)*

### 4.2.2 Effect on Crops

1. Where your crops damaged in the floods? ***Y[ ] N[ ]***
   If **Y**, please indicate the extent of damage to the crops in the table below.

| **Type of Crop** | **Extent of Damage relative to size of field** |
|---|---|
| | |
| | |
| | |
| | |
| | |

***Key for extent of damage****: 1= less than 20% completely destroyed; 2= up to 50% completely destroyed; 3=more than 50% completely destroyed*

## 5. Flood recovery

### 5.1 Direct non-NR contribution to flood recovery

1. Did you receive any grants to help you recover from the losses you suffered in the flood? ***Y[ ] N[ ]***
   If **Y**, please specify the name of the grant/ donor and the amount received.

| Name of Grant/ Donor | Amount Received (Rand) |
|---|---|
| | |
| | |
| | |

2. Did you receive any material aid to help you to recover from the losses you suffered in the flood? ***Y[ ] N[ ]***
   If **Y**, please specify the donor, the type of donation, and the quantities received.

| Donor | Donation | Quantity Received |
|---|---|---|
| e.g. local church | Maize meal | 1 bag |
| | | |
| | | |
| | | |
| | | |

### 5.2 Direct NR contribution to flood recovery

#### 5.2.1 Physical repairs

1. Did you use any NR to repair the physical damages to your property? ***Y[ ] N[ ]***
   If **Y**, please specify below which NR was used and how it was used in the repairs

| Type of NR used | Structure Repaired | Part of Structure Repaired |
|---|---|---|
| e.g. Wood | Fence | Poles |
| | | |
| | | |

#### 5.2.2 Sustenance

1. Did you have to substitute your diet with wild foods after your crop was destroyed? ***Y[ ] N[ ]***
   If **N**, why not?

______________________________________________________________________________

2. Did you sell any natural resources in place of your usual trading goods after they were destroyed in the flood in order to substitute income? ***Y[ ] N[ ]***

   If **N**, why not?

   If Y to either or both the questions above, please indicate in the table below the natural resource, whether it was used to substitute diet and/ or trade, and the relative contribution to substitution.

| **Natural Resource** | **Diet Substitute (Tick)** | **Sold (Tick)** | **Relative contribution** |
|---|---|---|---|
| e.g. wood | | | 2 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

***Key for relative contributions****: 1= less than 20%; 2= up to 50%; 3=more than 50%* ***of household income***

### 6. Other

1. Do you know of natural resources in your area? ***Y[ ] N[ ]***
2. Do you find it difficult to access natural resources? ***Y[ ] N[ ]***
3. If **Y**, then what reasons do you think account for this?
   a) *Distance from resources*
   b) *Policy regulation*
   c) *Lack of equipment to harvest them*
   d) *I do not know how they can benefit me*
4. *Have you used any natural resources to protect yourself against future floods?* ***Y[ ] N[ ]***
5. *If yes, how? Has it been effective so far?*

| **Natural Resource** | **Use** | **Effectiveness** |
|---|---|---|
| | | |
| | | |

| | | |
|---|---|---|
| | | |

***Key for relative effectiveness:*** *1= less than 20%; 2= up to 50%; 3=more than 50%*

## 6.1 Income

### 6.1.1 Education Level of Household

| **Name/ Code of Household Member *(see codes below)*** | **Age** | **Sex *(M=male F=female)*** | **Education *(number of years completed)*** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

***Codes****: 0=Head; 1=Father of head; 2= Mother of head; 3=Son/Daughter of head; 4=Grandchild of head; 5=Son/Daughter in law of head; 6= Other family members*

### 6.1.2 Formal employment

1. Which people in this household have a full-time, part-time or casual job? Please indicate details of employment in the table below.

| **Name Code** | **Job type** | **Full-time/part-time/casual** | **Self-employed (describe)** | **Local/ Remittance** | **R/month (if possible)** |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

***Codes****: 0= Head 1=Father of head; 2=Mother of head; 3=Son/Daughter of head; 4=Grandchild of head; 5=Son/Daughter in law of head; 6=Other family members*

### 6.1.3 Grants

1. Do you receive any grants in this household? ***Y[ ] N[ ]***
   If **Y**, please specify the name of the grant, the numbers received and amount in the table below.

| **Name** | **Tick** | **R/Month** | **No of Grants** |
|---|---|---|---|
| Old-age pension | | | |
| Disability grant | | | |
| Child grant | | | |
| Foster care grant | | | |
| Any other income *Specify*? | | | |

### 6.1.4 Trade

1. Do you sell any goods for cash? ***Y[ ] N[ ]***
2. If **Y**, please specify below which goods you sell, and how much money you make from them.

| **Goods Sold** | **Ordered for resale**<br>**(please tick)** | **Collected or produced (please tick)** | **Profit/ week** | **Profit/ month** | **Variable income- Specify** |
|---|---|---|---|---|---|
| Vegetables | | | | | |
| Eggs | | | | | |
| Fruit | | | | | |
| Milk | | | | | |
| Meat | | | | | |
| Firewood | | | | | |
| Wild fruits | | | | | |

***Thank you for your cooperation***.